WORKSHOP REPORT:

REVIEW OF ELECTRIC AND MAGNETIC FIELDS (EMFs)

MARCH, 2001

MANITOBA CLEAN ENVIRONMENT COMMISSION

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iv

TABLE OF CONTENTS

INTRODUCTION----1-1
BACKGROUND----1-1
APPROACH----2-1
WORKSHOP PARTICIPATION----3-1
EMF WORKSHOP AGENDA AND DISCUSSION----4-1
OVERALL AGENDA----4-1
OPENING----4-1
CONTEXT FOR REVIEW OF EMF TODAY----4-2
STATUS OF EMF RESEARCH----4-3
INT. COMMISSION ON NON-IONIZING RADIATION PROTECTION----4-5
REVIEW OF EXPERIENCE IN OTHER JURISDICTIONS----4-6
GENERAL DISCUSSION----4-8
CONSENSUS/RECOMMENDATIONS----5-1
APPROACH TO DEVELOPING POSTION STATEMENT----5-1
HEALTH AND EMF EXPERTS CONSENSUS STATEMENT----5-1
LINKS TO OTHER COMMITTEES/ORGANIZATIONS----5-3
MANITOBA HYDRO'S EMF PUBLIC INFORMATION BROCHURES----5-3
QUESTION/ANSWER EMF DOCUMENT----5-3
PRODUCTS AND SCHEDULES----5-4
FOLLOW-UP----5-4
CONCLUSIONS----6-1
REFERENCES----7-1

LIST OF APPENDICES

APPENDIX A	Invitation to Experts
APPENDIX B -	Questionnaire and Contact List
APPENDIX C -	Context for Review of EMF Today
APPENDIX D -	EMF: A Public Health Overview
APPENDIX E -	International Commission on Non-Ionizing Radiation Protection (ICNIRP)
APPENDIX F -	Review of Experience: How Other Jurisdictions Deal With EMF Concerns
APPENDIX G -	Federal-Provincial-Territorial Radiation Protection Committee (FPTRPC) Position Statement – 1998
APPENDIX H -	General Discussion

1. INTRODUCTION

On November 15, 2000, the Manitoba Clean Environment Commission (CEC) received a request from the office of the Minister responsible for Manitoba Hydro (the Minster) to undertake an investigation of the potential human health-related effects that might be associated with electric and magnetic fields (EMFs) as emitted from transmission and distribution lines. This assessment of the health-related EMF issue was also to include the review of practices used in other jurisdictions in responding to EMF concerns. The CEC (the CEC Panel) directed and facilitated a process that addressed the Minister's request.

The initial intent was to conduct a literature review of the EMF issue. After considering this approach, the CEC Panel determined that a more appropriate and effective process would be to organise a workshop that would bring together public health officials and experts on EMF (the Experts) to review and discuss the potential human health-related effects of EMF. Accordingly, on January 25, 2001 the Commission convened an Experts Workshop to provide a forum in which to discuss the human health effects of EMFs and to determine if any conclusions could be drawn from the extensive studies and research that has been conducted on this issue over the past 30 years. In addition to public health and EMF experts, the Workshop was attended by three Commission members along with representatives from both Manitoba Hydro and Manitoba Conservation who served as a technical resource to the CEC during the Workshop.

This report outlines the findings of the EMF Workshop and is supplementary to the report entitled, "Electric and Magnetic Fields (EMFs): Health and EMF Experts Consensus Statement" (CEC 2001).

1.1 BACKGROUND

Electric and magnetic fields (EMFs) occur naturally and as a result of the generation, delivery and use of electric power. EMFs are fields of force created by electric voltage and current. The earth has natural electric and magnetic fields.

Electric fields emanate from electrical appliances and from their power supply cords. Electric fields are a function of the voltage on a conductor and can exert a force on charged objects near

them. The strength of electric fields is typically measured in volts per metre (V/m) or in kilovolts per meter (kV/m). The strength of an electric field decreases significantly with increasing distance from the source.

Magnetic fields result primarily from the motion of the electric charge or current, such as when there is a current flowing through a power line or when an appliance is plugged in and turned on. Magnetic fields are typically measured in tesla (T) or in gauss (G) and milligauss (mG). One tesla equals 10,000 gauss and one gauss equals 1,000 milligauss.

The EMF from power lines and appliances are of extremely low frequency (ELF) and low energy. They are non-ionizing and are markedly different in frequency from ionizing radiation such as X-rays and gamma rays. Extremely low frequency electric and magnetic fields (ELF-EMFs) do not have enough energy to heat body tissue or cause ionization, i.e., form charged particles that could more readily be absorbed by biological matter.

Over the past 30 years, questions have been raised about the possible human health-related effects associated with exposure to EMFs from electric power lines, home wiring and electrical devices such as appliances, televisions and computer monitors. Numerous studies and investigations have been undertaken in an attempt to define possible human health-related effects.

2. APPROACH

Initially, in determining the most appropriate approach to the investigation of the possible human health impacts associated with exposure to EMFs, the CEC considered conducting a literature review to examine the state of the scientific debate on the matter. Currently, there are an estimated 27,000 reports and publications respecting EMF. Given the volume and technical complexity of the material the Commission determined that its proper interpretation would require the involvement of experts that work in the fields of public health and EMF research.

After discussing the overall scope and limitations associated with a literature review, the CEC determined that the convening of an Experts Workshop to consider the EMF issue would be a more efficient and effective process through which to achieve a practical understanding of the topic. It was also reasoned that such an approach would facilitate the preparation of a useful interpretation of the issue for government. Accordingly, the Commission convened such a Workshop on January 25, 2001 (ref. Appendix A).

The focus of the EMF Workshop was to discuss "the state of the debate" on EMF and, if appropriate, to develop an Expert's Consensus Statement on the issue of human health-related effects of exposure to EMFs from electrical transmission and distribution lines. Mr. Terry Duguid, Commission Chairman, acted as a facilitator for discussions that occurred at the one-day Workshop. Dr. Jack Mandel, a recognised expert in the EMF field of study, gave a presentation and interpretation of the potential human health-related effects of exposure to EMFs. His presentation was based on the findings of 30 years of studies on the topic by various researchers and 20 years of personal involvement in the field.

The Workshop participants also considered the guidelines respecting EMF exposure as established by the International Commission on Non-Ionizing Radiation Protection (ICNIRP), as provided by Dr. Johnson of CancerCare Manitoba. This presentation was intended to provide a basic understanding of the ICNIRP guidelines and an interpretation of how they potentially apply to Canada and, more specifically, to Manitoba.

The practices used in other jurisdictions to respond to EMF concerns were also discussed at the EMF Workshop. This included a report on the findings of a Tetr*ES* Consultants Inc. telephone survey respecting the various strategies developed across Canada in response to EMF issues

and concerns (ref. Appendix B). (EMF policies in the U.S.A. and select European countries were explored through a review of existing information, but not through phone surveys.)

The majority of funding for this investigation was provided by the Clean Environment Commission. Pursuant to Environment Act Regulation 210/92, the Commission sought cost recovery from Manitoba Hydro to secure the services of Dr. Mandel. Manitoba Hydro played no role in the selection of any of the Experts who attended the Workshop, including Dr. Mandel.

3. WORKSHOP PARTICIPATION

The Experts Workshop convened by the CEC involved a number of public health officials and EMF Experts. Various technical and administrative staff were also in attendance along with three members of the Commission.

Health and EMF Experts

Dr. Jack Mandel, Vice President, Exponent Health Group Inc.

Dr. Harry Johnson, Department Head, Imaging Physics & Radiation Protection, CancerCare Manitoba

Dr. Margaret Fast, Medical Officer of Health, Winnipeg Regional Health Authority

Dr. Jim Popplow, Manitoba Officer of Health, Public Health Branch, Manitoba Health

Clean Environment Commission

Terry Duguid, Chairman

Gerard Lecuyer

Ian Halket

Technical Resources

John Chan, Section Head, Transmission Design, Manitoba Hydro

Brian Blunt, Environment Officer, Land Conservation Use Approvals, Manitoba

Consulting and Support Staff

George Rempel, President, Tetr*ES* Consultants Inc.

Blair McMahon, Senior Biologist, Associate, Tetr*ES* Consultants Inc.

Shaun Loney, Special Assistant, Minister Responsible for Manitoba Hydro

James Potton, CEC Technical Advisor

Rory Grewar, Commission Secretary

4. EMF WORKSHOP AGENDA AND DISCUSSION

4.1 OVERALL AGENDA

The EMF Workshop was organised to include a series of presentations, followed by a general discussion leading to the possible development of a consensus on the interpretation of the information presented at the Workshop. The meeting agenda covered the following:

- Introduction – an opening to the workshop was provided by Terry Duguid, Chairman of the Manitoba Clean Environment Commission (CEC);
- Context for review of EMF Today – presentation provided by George Rempel of Tetr*ES* Consultants Inc.;
- EMF: A public health overview – presentation provided by Dr. Jack Mandel of Exponent Health Group Inc.;
- International Commission on Non-Ionizing Radiation Protection (ICNIRP) – presentation provided by Dr. Harry Johnson of CancerCare Manitoba;
- Review of experience: How jurisdictions deal with EMF concerns – presentation provided by Blair McMahon of Tetr*ES* Consultants Inc.;
- Discussion/Consensus: Observations and recommendations;
- What's next; and
- Closing Comments – provided by Terry Duguid.

Open-ended discussion, with questions and answers, occurred following the presentations. The presentations are provided in Appendices C through F. Relevant discussions relating to each of the above-mentioned agenda items are provided in the following sub-sections.

4.2 OPENING

Terry Duguid gave the opening remarks, welcoming those in attendance. He gave some background on the Manitoba Clean Environment Commission, and indicated that the CEC provides advice and recommendations to the Province of Manitoba with respect to many

activities, including the following:

- public hearings for environmental licenses, e.g., major proposed developments;
- environmental mediations;
- issues investigation, e.g., the current human health-related EMF issue; and
- public education programs, e.g., the recent climate change forum.

Mr. Duguid indicated that the purpose of this EMF Workshop was to address the questions asked by the office of the Manitoba Minister responsible for Manitoba Hydro (the Minister) and in so doing reflect the current state of the debate on the potential human health-related effects that might be associated with electric and magnetic fields (EMFs). Since the Minister also requested an identification of practices used in other jurisdictions to deal with EMF concerns, information in this regard would also be included in the Workshop process.

Mr. Duguid indicated that, following the EMF Workshop, a Manitoba Clean Environment Commission report would be written and provided to the Minister.

4.3 CONTEXT FOR REVIEW OF EMF TODAY

George Rempel provided a presentation (ref. Appendix C) that gave a perspective on the following topics:

- electric power generation and distribution - in general and with respect to proposed development in Manitoba;
- definition of electric and magnetic fields;
- typical magnetic field strengths in Winnipeg;
- electric and magnetic field strength along and near transmission line rights-of-way and how EMF exposure levels are typically well below the International Commission on Non-Ionizing Radiation Protection (ICNIRP) guideline limits outlined in Section 4.5;

4.4 STATUS OF EMF RESEARCH: A PUBLIC HEALTH OVERVIEW

Dr. Jack Mandel provided a presentation regarding the potential human health-related effects that might be associated with EMFs. Dr. Mandel is a Group Vice President at Exponent Health Group Inc., primarily responsible for directing the nationwide operations of the health and environmental practices of the firm. Dr. Mandel has been a member of the University of Minnesota faculty since 1975. From 1995 to 1999, he was the Head of the Division of Environmental and Occupational Health in the School of Public Health at the University of Minnesota. Dr. Mandel has conducted many case-control, cohort (both prospective and retrospective), cross-sectional, experimental, and methodological studies. He has published more than 100 articles related to epidemiology, including studies of prostate, colorectal, kidney, pancreatic, breast, lung, stomach, haematopoietic and skin cancers. These studies have evaluated a variety of potential causes for illness due to exposures through occupation, radiation, pesticides and other chemicals, hormones, medications, diet, alcohol, and tobacco, as well as other lifestyle factors.

Dr. Mandel explained that although extensive studies addressing the possible effects of exposure to EMFs have been conducted over the past 30 years, interpretation of the results have often provided a "mixed message" regarding the presence or absence of a causal link between extremely low frequency (ELF) electric and magnetic fields (as produced by electric power distribution and transmission lines) and any potentially adverse effects on human health. Dr. Mandel provided an overhead presentation of more than 60 slides (ref. Appendix D) that included a description of the origin of the EMF concerns (i.e., studies by Wertheimer and Leeper [1979], and Savitz *et. al.* [1988]), as well pertinent information described below in summary.

4.4.1 Scientific Methods for Evaluating EMFs

- the role of science in public health, regarding the investigation and interpretation of studies, including assessment of limitations;
- the manner in which scientists test predictions relating to EMFs with respect to epidemiologic studies in humans, laboratory studies in animals, and studies of cells and tissues; and

- epidemiology studies to compare characteristics of people with/without a disease:
  - individual characteristics modifying the effect of environmental factors;
  - a definition of statistical association and confounding factors;
  - studies of residential exposures from power lines and of electrical workers; and
  - the serious methodological errors that have been made in several key studies used by some for rationalizing a causal link between EMF and cancer.

4.4.2 EMF Research Findings

- recent studies that support the conclusion that there is no demonstrable causal association between leukemia and wire codes;
- the NCI (National Cancer Institute) study of over 600 cases (i.e., individuals tested in the study) in 9 states that showed no demonstrable causal association between EMF and childhood leukemia for any exposure method (Linet *et al.* 1997; Kleinerman *et al.* 2000), regardless of wire coding, distance, exposure index, and measured dose. There was a positive association for .400-.499 μT in 10 cases and 2 controls;
- the NCI conclusions that there was no demonstrable causal effect of EMF in promoting cancer;
- the results of McBride (*et al.* 1999) study that support the conclusion that there is no causal effect of EMFs on the risk of childhood leukemia;
- the conclusions of Green *et al.* (1999) that wire coding is not related to increased health risks from EMFs but that the results suggest an association between magnetic fields (MFs) and risk of developing childhood leukemia:
  - several methodological problems exist for that study, e.g., case and control selection, confounding factors considered, etc.;
- the United Kingdom Childhood Cancer Study (UKCCS) study by Sir Richard Doll (UKCCS Investigators 2000):
  - involved 2,226 cases and 2,226 controls in Stage 1 of study;
  - involved 3,800 cases and 3,800 controls in Stage 2 of study;
- the conclusion of investigators from the UKCCS study, that "*...found no evidence that magnetic fields associated with the electricity supply increase risk of childhood leukemia, malignant brain (or other central nervous system) tumours, or any other childhood cancer*" (UKCCS Investigators 2000);
- the problems associated with pooled (meta) analyses and how results are inconclusive;

- three recent studies showing no association between electric blanket use and breast cancer;
- occupational epidemiology and how, in over 100 studies, no causal relationship between EMFs and cancer has been established; and
- how lab research studies suggest no causal link between cancer and EMF, even given the controlled nature of the experiments and the use of extremely high EMF exposures up to 50,000 mG (milligauss).

4.4.3 EMF Position Statements and Classification Systems

- the Federal-Provincial-Territorial Radiation Protection Committee (FPTRPC) Position Statement of 1998;
- the use of the International Agency for Research on Cancer (IARC) classification system to define a "weak association" between EMF and cancer; and
- the National Institute of Environmental Health Sciences (NIEHS 1999) statements and how consensus was required among opposing views.

4.4.4 Overall Interpretations of EMF Studies

- Sir Richard Doll's conclusion that there is no causal link between EMF and cancer and no justification for conducting further epidemiological studies on EMF and childhood cancer in Britain (UKCCS Investigation, 2000); and
- Dr. Jack Mandel support of Doll's position that there is no causal relationship between EMF and cancer.

4.5 INTERNATIONAL COMMISSION ON NON-IONIZING RADIATION PROTECTION (ICNIRP)

The Health and EMF Experts at the Workshop also considered the guidelines regarding exposure to EMFs as prepared by the International Commission on Non-Ionizing Radiation Protection (ICNIRP). ICNIRP is an international and independent body comprised of specialists in the field of EMF research, whose function is to provide recommendations on "health-based"

guidance to limit exposures to EMF. Dr. Harry Johnson of CancerCare Manitoba provided an overhead presentation (ref. Appendix E) that, in summary, included a description of:

- the electro-magnetic (EM) spectrum and a description of the zone of ionizing and non-ionizing radiation, and that ELF is a force field, not radiation;
- the history of ICNIRP – including a description of the commission and the history of the International Radiation Protection Association, International Commission on Non-ionizing Radiation Protection (ICNIRP) and Non-Ionizing Radiation Working Group;
- the limits regarding health effects, the classes of guidelines, the frequencies covered by the guidelines, time-varying fields, safety factors, exposure limits and physiological responses to ELFs; and
- the guideline that recommends a limit of 4.16 kV/m and 83.3μT (833 milligauss) for 24-hour exposure of the general public (ICNIRP 1998).

Dr. Johnson explained that following the publication of the ICNIRP (1998) guidelines, several institutions criticized the guidelines as lacking clear interpretation on exposure safety or direct application. Dr. Johnson believes that the ICNIRP guidelines are overly conservative. He does not advocate the acceptance of ICNIRP guidelines in Manitoba.

4.6 REVIEW OF EXPERIENCE: HOW JURISDICTIONS IN CANADA AND ELSEWHERE DEAL WITH EMF CONCERNS

The Workshop also considered how other Canadian jurisdictions deal with the EMF issue. Blair McMahon of Tetr*ES* Consultants Inc. provided an overhead presentation (ref. Appendix F) that, in summary, included a description of topics outlined below.

4.6.1 Phone Survey Results

The results from a phone survey involving 22 individuals contacted across Canada revealed the following:

- there are no Canadian ELF-EMF guidelines at present or in development;
- there are no avoidance policies for siting transmission lines based on EMF;

- agencies refer to existing guidelines, e.g., the Federal-Provincial-Territorial Radiation Protection Committee (FPTRPC) statements, ICNIRP and IEE (Institution of Electrical Engineers) draft guidelines; and
- that information on EMFs are disseminated and, where appropriate, monitoring occurs.

4.6.2 EMF Position Statements, Guidelines and Policies

There currently are no province-specific guidelines or legislation in Canada that identifies acceptable levels of EMFs emanating from transmission and distribution lines, i.e., extremely low frequency (ELF) electric and magnetic fields, typically 60 Hz in Canada. The provincial governing bodies in Canada currently do not have provincially established standard practices in responding to EMF-related concerns that are based on a definition of acceptable levels of EMFs. When dealing with EMF issues, most provincial authorities in Canada reference other federal and international guidelines, including the:

- Federal-Provincial-Territorial Radiation Protection Committee (FPTRPC) Position Statement of 1998 (ref. Appendix G). This Position Statement, which is currently under review, is developed on the basis of the following conclusion: "*The research taken overall indicates that the evidence is insufficient to conclude that electric or magnetic fields cause a risk of cancer*";
- ICNIRP (International Commission on Non-Ionizing Radiation Protection) guidelines;
- IEE (Institution of Electrical Engineers) draft guidelines; and
- Health Canada guidelines (Safety Code 6), which does not set standards for EMFs below 3 kHz.

Some Canadian organizations, such as Ontario Hydro, have responded to concerns regarding EMFs by hosting community meetings to discuss the issue. B.C. Hydro adopted the approach of giving concerned citizens the metering devices needed to measure EMF fields.

The approach used by Manitoba public health and Manitoba Hydro representatives in responding to individuals having EMF concerns is consistent with the approach followed in other Canadian provinces and territories. When concerns regarding EMFs are directed to the provinces of Manitoba, Saskatchewan and Ontario (ref. Appendix F), provincial authorities first refer to the 1998 Position Statement developed by the FPTRPC. ICNIRP guidelines may be

referred to as an international standard on EMF exposure levels. If the information does not alleviate the concern, provincial representatives will on occasion send out a technician to take measurements to determine the level of EMF at a site.

4.7 GENERAL DISCUSSION

Discussions regarding electric and magnetic fields (EMFs) occurred following the presentations. A question and answer period occurred near the end of the Workshop. Relevant points of general discussions that occurred during the workshop are described in greater detail in Appendix H.

Discussions that occurred during the EMF Workshop focussed on the following topics:

- The results and conclusions from key EMF-related health studies, namely the National Cancer Institute (NCI) study and the United Kingdom (UK) study;
- the relationship between transmission lines and EMF exposure levels;
- the interpretation of international guidelines on EMF and their potential suitability for application in Manitoba; and
- how Canadian jurisdictions deal with EMF concerns.

4.7.1 Results and Conclusions of Key EMF Studies

Questions were raised regarding the confidence that Dr. Mandel and the scientific community in general have with regard to findings of some key EMF-related health studies, including the National Cancer Institute (NCI) study (Linet *et al.* 1997; Kleinerman *et al.* 2000) and the United Kingdom study (UKCCS Investigators 2000). Dr. Mandel explained how these well-designed studies provide definitive evidence that supports the conclusions of Sir Richard Doll and other investigators that there is no demonstrable causal link between extremely low frequency (ELF) electric and magnetic fields (EMFs) and cancer (ref. Appendix H).

4.7.2 Transmission Lines and EMFs

Workshop participants asked questions regarding whether EMF exposure levels along transmission line rights-of-way comply with existing international guidelines and hydroelectric standards. John Chan of Manitoba Hydro explained that magnetic field exposure levels emanating from transmission lines in Manitoba are within the international guideline limits established by the international Commission on Non-Ionizing Radiation Protection (ICNIRP). Manitoba Hydro adheres to occupational safety limits specified in the Canadian Standards Association (CSA) guidelines ensuring worker safety near electric fields (ref. Appendix H). Mr. Chan further indicated that presently there are no cost-effective ways of reducing EMF emission from transmission lines using different technical designs – such as through burying transmission lines.

4.7.3 Electric and Magnetic Field (EMF) Guidelines

Responding to questions regarding the interpretation of international guidelines on EMFs and whether they are suitable for application in Manitoba Dr. Johnson explained how the ICNIRP guidelines define an exposure limit at which a physiological response occurs. This does not necessarily mean that someone exposed to that level will develop a health-related problem such as cancer, because there has been no demonstrable causal relationship between EMFs and any adverse human health effects related to exposure. According to Dr. Johnson, the relationship that Manitoba and Canada should potentially have with ICNIRP, and whether to adopt the ICNIRP guidelines, is voluntary. Dr. Johnson suggested that the ICNIRP guidelines are overly conservative. He does not advocate the acceptance of ICNIRP guidelines for use as exposure limits for the public in Manitoba.

4.7.4 How Canadian Jurisdictions Deal With EMF Concerns

In response to the presentation on how jurisdictions across Canada and elsewhere deal with EMF concerns and how this relates to the Manitoba experience Dr. James Popplow of Manitoba Health indicated that he typically explains to individuals having an EMF-related concern the current thinking on EMF - that there is no causal relationship between EMF and

cancer. Manitoba Hydro typically responds to individuals having an EMF-related concern by providing them with an EMF pamphlet and, in some instances, by putting that individual in contact with Dr. James Popplow. The approach currently followed by Manitoba representatives in responding to individuals with EMF-related concerns is consistent with the approach followed by representatives from other Canadian provinces and territories.

5. CONSENSUS/RECOMMENDATIONS

Following extensive discussion at the EMF Workshop consensus was reached that a Position Statement (Consensus Statement) would be prepared by the Health and EMF Experts (the Experts) in attendance. In addition, a number of suggestions were put forward by the Workshop participants as appropriate recommendations to be considered by the Manitoba Clean Environment Commission.

5.1 APPROACH TO DEVELOPING THE POSITION STATEMENT

It was agreed that the FPTRPC Position Statement (1998) on EMF would be utilized as an initial guide towards developing an Expert's Consensus Statement flowing from the EMF Workshop discussions. It was generally agreed that wording in the statements would reflect the current understanding of the potential effects of EMF on human health. It was thought that the Consensus Statement that was formulated by the Health and EMF Experts could be considered for use as a guide for health care professionals in Manitoba.

Following extensive discussions the Consensus Statement outlined in Section 5.2 was developed. This statement builds on the FPTRPC statement (ref. Appendix G)and adds more definite wording where deemed acceptable by the Workshop Experts.

5.2 HEALTH AND EMF EXPERT'S CONSENSUS STATEMENT ON THE HUMAN HEALTH EFFECTS OF EXTREMELY LOW FREQUENCY ELECTRIC AND MAGNETIC FIELDS

1. The production of electric and magnetic fields (EMFs) is associated with the generation, transmission and use of electricity. People are exposed to these fields not only when they are near high voltage lines, but also at their places of work and in their homes. Such fields are produced by distribution lines, transformers, building and house wiring and by all devices that use electric power.

2. Studies to investigate the potential health effects of these fields have been performed around the world for more than 30 years. Such research has included laboratory studies of

cells, tissues and animals, as well as studies of human exposure in epidemiological studies.

3. The weight of scientific evidence does not support the conclusion that extremely low frequency EMFs such as those produced by power lines are a cause of adverse effects on human health.

4. Research to date[1] has not confirmed any biophysical mechanisms that would link properties of power and frequency fields to the initiation or promotion of cancer or any other adverse effect on human health.

5. Recommended exposure limits to prevent acute health effects at high levels of exposure have been put forward by members of the International Commission on Non-Ionizing Radiation Protection (ICNIRP)[2]. ICNIRP has not determined that chronic exposures at lower exposure levels are adverse. As recommended by the European Commission, member jurisdictions are to implement these ICNIRP exposure limits on EMFs with the proviso that the ICNIRP recommendations apply "to relevant areas where members of the public spend significant time."[3] Currently available information on health and bioeffects of extremely low frequency fields does not provide a basis for establishing more restrictive exposure limits.

6. The Federal Provincial Territorial Radiation Protection Committee (FPTRPC) should continue to monitor the results of new studies, to re-assess their position in 2001 and in the future as new information becomes available, and to keep the Province of Manitoba apprised of their progress through the FPTRPC representative in Manitoba.

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[1] Refer to Clean Environment Commission EMF Workshop Report (2001). Also to the Council of the American Physical Society – (85/04/22).

[2] ICNIRP Guidelines "Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields (up to 300 GHX)," Health Physics, Vol. 74, No. 4, pp. 494-522, April 1998. The guidelines recommend a limit of 4.16 kV/m and 83.3 μT (833 milligauss) for 24-hour exposure of the general public.

[3] EU (European Union): COUNCIL RECOMMENDATION of 12 July 1999 On the Limitation of Exposure of the General Public to Electromagnetic Fields (0 Hz to 300 GHz) (1999/519/EC). Official J. Eur. Comm. L199:59-70(1999).

5.3 LINKS TO OTHER COMMITTEES/ORGANIZATIONS

Dr. Johnson advised that the Federal-Provincial-Territorial Radiation Protection Committee (FPTRPC) will meet in October 2001, and the larger committee might accept the work of the FPTRPC sub-committee examining ELF-EMF guidelines. As a member of the main body of the committee, he agreed to act as a link to the FPTRPC process on behalf of Manitoba.

Dr. Popplow indicated that he would advise members of the Federal-Provincial Committee for Occupational Health (FPCOH), for which he is a member, of the results of the CEC-sponsored Experts Workshop.

5.4 MANITOBA HYDRO'S EMF PUBLIC INFORMATION BROCHURES

In 1991 Manitoba Hydro produced pamphlets for the public on EMFs indicating that the literature on health-related effects of EMFs are inconclusive. John Chan advised that this literature was produced in response to the EMF issue as related to proposed development of Bipole III in the early-1990s (as a component of the sale of power from the previously proposed Conawapa Generating Station on the Nelson River to Ontario). Mr. Chan suggested that the EMF literature produced previously by Manitoba Hydro is dated and that he would take steps towards updating that information. Mr. Chan indicated that Hydro would update their EMF brochure.

5.5 QUESTION / ANSWER EMF DOCUMENT

There was consensus that information produced and provided by a public health agency would be perceived as more credible than that provided by an electrical utility. Dr. Popplow agreed to take the lead in developing a Question and Answer (Q & A) document regarding EMF for the general public. He suggested using a health protection Q/A document produced by Health Canada as a guide, with comments to be added to update the position. The National Institute of Environmental Health Sciences (NIEHS) Q/A document, as a component of the EMF Rapid Program in the U.S., could also be used as a background piece in formulating a Q/A document.

5.6 PRODUCTS AND SCHEDULES

Products from the Workshop would include:

- a Manitoba Health and EMF Experts Consensus Statement regarding Electric and Magnetic Fields to be prepared in draft form by the end of January, was targeted for mid-March 2001 for final production. This report summarizes key discussions relevant to the Consensus Statement developed by the Experts; and
- a Manitoba EMF Workshop Report that outlines in more detail the discussions of the Workshop, including the provision of presentation material in appendices. It was agreed that the target date for completion would be mid-March.

5.7 FOLLOW-UP

From late January through early-March 2001, drafts of the Health and EMF Experts Consensus Statement were provided to each of the experts in attendance at the EMF Workshop for review and comment. Consensus was reached between the Manitoba public health professionals and the EMF experts (that attended the Workshop) with respect to the wording of the EMF Consensus Statement prior to the writing of this report.

Following the EMF Workshop of January 25, 2001, EMF Experts received and reviewed recent reports (e.g., Havas 2000; O'Dell and Wasti 2000), National Radiation Protection Branch response statements and press releases that were not discussed at the workshop. After reviewing these documents, Dr. Mandel indicated that the conclusions and the Consensus Statement remain valid - that the weight of scientific evidence supports the conclusion that there is no demonstrable causal effect of extremely low frequency electric and magnetic fields, such as those produced by power lines, on any adverse human health-related outcome, including cancer.

6. CONCLUSIONS

After considering the state of the current research, as summarized by Dr. J. Mandel at the EMF Workshop of January 2001, the Health and EMF Experts felt that the weight of evidence is compelling. There is a definitive pattern of consistency and statistical strength in the findings of well-designed studies (epidemiologic and laboratory) over the past 30 years, particularly recently published studies (including the UK study directed by Sir Richard Doll) that support the conclusion that there is no demonstrable effect on human health from EMFs.

The Experts do not advocate the acceptance of the guidelines established by the International Commission on Non-Ionizing Radiation Protection for use as exposure limits for the public in Manitoba.

The Experts reached consensus on the need for a Consensus Statement to be developed on behalf of the Manitoba Clean Environment Commission (ref. Section 5.2). This Consensus Statement is primarily intended to assist public health officials in Manitoba in responding to concerns the public may express regarding EMFs.

In addition to the Consensus Statement respecting the human health related effects of exposure to EMF, the following suggestions were put forward as appropriate recommendations for action by the Manitoba Government:

(1) That the Manitoba representative of the Federal-Provincial-Territorial Radiation Protection Committee (FPTRPC) submit the Consensus Statement on EMF to the FPTRPC for their consideration during review of the 1998-position statement.

(2) That Manitoba Hydro update its brochures and public information regarding EMF.

(3) That Manitoba Health develops a "reader-friendly" *Question and Answer* brochure regarding EMF and human health, to be used in general public distribution.

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Note: The above list of references includes literature cited in the main body of the report and the appendices. A list of contacts and personal communications associated with responses to the questionnaire and to other forms of communication is provided in Appendix B.

APPENDIX A

INVITATION TO EXPERTS

Clean Environment Commission

305 –155 Carlton
Winnipeg, Manitoba CANADA
R3C-3H8

(204) 945-7498
(204) 945-0090 (FAX)

January 18, 2000

Dear

Thank you for agreeing to participate in the upcoming Electro–Magnetic Fields (EMF) Experts meeting scheduled for January 25th at the Winnipeg Convention Centre. This meeting will involve a small group of approximately15 participants.

The planning for this session is the result of a request mad of the Clean Environment Commission (CEC) by the Minister of Finance to undertake an "investigation of the potential human health related impacts associated with electro-magnetic fields as emitted from transmission and distribution lines". As part of the same request the Commission was asked to include "an identification of practices used in other jurisdictions to deal with EMF concerns".

The intent of this meeting is to determine "the state of the debate" on EMF and to produce a consensus document summarizing the most current and accepted position(s) with regard to EMF health impacts.

Confirmed participants include the eminent epidemiologist, Dr. Jack Mandel, Group Vice President of Exponent Consultants Inc., New York, NY with responsibility for directing nationwide operations of the firms health and environmental practices activities, a panel comprised of 3 CEC Commissioners with myself as Chair, health experts (including Manitoba Health, Cancer Care Manitoba, and the Winnipeg Regional Health Authority) and CEC staff. Attending as a resource to the participants will be representatives from Tetr*ES* Consulting Inc., Manitoba Conservation, Manitoba Hydro, and Manitoba Finance.

Underground parking is available and both a continental breakfast and lunch will be provided. Basic information including public handouts from Manitoba Hydro, Health Canada and a briefing note prepared by Dr. Harry Johnson respecting the International Commission on Non-Ionizing Radiation Protection (ICNIRP) is either attached or will have already been provided to you. The proposed agenda for the day is attached.

Contact Jim Potton 945-7498 or Rory Grewar 945-7091 if you have any questions.

I look forward to your participation in this very important meeting.

Terry Duguid, Chairman

Manitoba Clean Environment Commission

Clean Environment Commission investigation

"Electro-magnetic Fields and Health"

Call for "Expert" Participation

The Clean Environment Commission (CEC) has been requested by the Office of the Minister responsible for Manitoba Hydro to undertake an" investigation of the potential human health related impacts associated with Electro-magnetic fields as emitted from transmission and distribution lines". The CEC has also been requested to include "an identification of practices used in other jurisdictions to deal with EMF concerns".

Although the initial request was to undertake the investigation as a literature review, the Commission is proceeding instead with a one day "Experts Meeting" that will take the form of a workshop with a small CEC Panel as well as local health officials. Based upon the meeting, a consensus report will be provided to the Minister responsible for Manitoba Hydro. Presumably this document would be made available publicly for any future discussions with respect to new or expanded transmission and distribution lines in Manitoba.

The Commission is undertaking this initiative in a tight timeline and are targeting for a mid January "Experts Meeting". The session would be geared for approximately one dozen individuals as a full day session. The intent is to involve the key Manitoba Health experts with assistance from an internationally renowned expert on EMF. Manitoba Hydro will be requested to serve as a resource to meeting that will be chaired by the Clean Environment Commission.

You have been identified as a key individual to participate in this meeting and the CEC seek your consideration to be involved in this very important initiative.

Might you give the matter some consideration and if you are interested and available to participate, please contact me so that a formal letter of request can be provided under the signature of the Chairman of the Clean Environment Commission.

Our target date would be for the week of January 15th and therefore we would like an early indication of your interest in participating, as well as an indication of your availability for a full day during both the week of as well as the week of January 22.

Thanks for your consideration.

Jim Potton
Sr Professional Officer
945-7498 FAX – 945-0090

APPENDIX B

QUESTIONNAIRE AND CONTACT LIST

EMF QUESTIONNAIRE
January 2000

Date:_____ Person Contacted:_____

Phone No:_____ Fax No.:_____ E-mail:_____

Agency:_____ Province/State:_____

Mailing Address:_____ Contact by: B. McMahon

Preface: I am working for TetrES Consultants, whom have been given a task by the Manitoba's Clean Environment Commission to examine the health related effects and jurisdictional policies regarding Electric Magnetic Fields (EMFs) associated with transmission and distribution lines. Manitoba Hydro has proposed building numerous transmission lines and EMF concerns have been raised in the course of the environmental review process. Accordingly, the CEC is conducting a brief review of the issue and conducting a survey of what other jurisdictions are doing regarding this issue. I want to ask you questions regarding the practices and policies that your provincial (/state) uses to deal with EMF concerns and transmission lines.

1a. Can you please answer a few questions regarding EMF and transmission?

Yes No Call back

1b. If no, can you suggest other people to contact:_____

_____

2a. How often does your agency deal with EMF concerns? _____

2b. What other people or agencies deal with EMF concerns for your province?

_____

3a. What are the main public/government concerns that are addressed by you or your agency with respect to EMFs and tranmission (and distribution) lines?

_____

_____

3b. Is there a standard guideline or process in place to address various EMF concerns and issues as they arise? (For example, is one person or agency assigned with the task and do they follow a protocol such as mailing out brochures to concerned people)

Yes No Uncertain

3c. If yes, describe the protocol:_____

_____

_____

4a. Does your province (state) currently have an objective or guideline to define acceptable levels of EMFs?

Yes No Uncertain

4b. If yes, describe the objectives/guidelines regarding transmission/distribution lines:_____

_____

_____

5a. Have any plans been tabled within the provincial (state) government to develop objectives or guidelines to define acceptable levels of EMFs?

Yes No Uncertain

5b. If yes, describe the plans and contact person(s):_____

_____

_____

6a. Does your province (state) have an avoidance policy for the siting of transmission or distribution power lines with respect to EMF?

Yes No Uncertain

6b. If yes, please describe the policy:_____

_____

_____

7a. Are there any publications regarding your province's (state's) practices for dealing with EMF concerns?

Yes No Uncertain

7b. If yes, please list the names of the documents, the source where I can acquire a copy and, if feasible, please send me a copy (mail, fax or e-mail):

_____

_____

8a. Are there other people you would suggest that I speak to regarding EMF?

Yes No Uncertain

8b. If yes, list the names and contact locations:_____

_____

_____

Thank you for taking the time to answer these questions.

TABLE C-2

CONTACT LIST

Name	Agency	City	Province / State
Brian	Workplace Health and Safety, Alberta Human Resources and Employment	Edmonton	Alberta
Joyce Didier	Alberta Energy and Utilities Board	Calgary	Alberta
Brian Phillips	Dept. of Health Radiology	Vancouver	B.C.
Gregory Quan	B.C. Hydro	Vancouver	B.C.
Randy Ross	Ministry of B.C.	Vancouver	B.C.
Cheryl Franz	Workplace Safety and Health Division, Manitoba Labour	Winnipeg	Manitoba
Johnson	Cancer Care Manitoba	Winnipeg	Manitoba
Jim Popplaw	Department of Environment	Winnipeg	Manitoba
	Workplace Safety and Health Division, Manitoba Labour	Winnipeg	Manitoba
Paul Reid	of New Brunswick	Fredericton	New Brunswick
Robert Burn	and Labrador	St. John's	Newfoundland
Duane Flemming	Northwest Territories Dept. Health Protection Unit		Territories
Gord Beckett	Northwest Territories Workers Compensation Board		Territories
Viki Laferty	Northwest Territories Dept. Health		Territories
Duncan McKay	Department of Environment		Nova Scotia
	Service Nova Scotia & Municipal Relations	Halifax	Nova Scotia
Eric Lamay	Health Canada, Radiation Protection Bureau	Ottawa	Ont
Wanda Howe	Canadian Centre for Occupational Health and Safety	Ottawa	Ontario
	Ontario Energy Board	Toronto	Ontario
Wayne Tiessen	Occupational Health and Safety Division, Saskatchewan Labour	Regina	Saskatchewan

APPENDIX C

CONTEXT FOR REVIEW OF EMF TODAY

CONTEXT: REVIEW OF ELECTRIC & MAGNETIC FIELDS

SOME TERMS

EMF – Electric and Magnetic Fields associated with the transmission, distribution, and use of electrical power

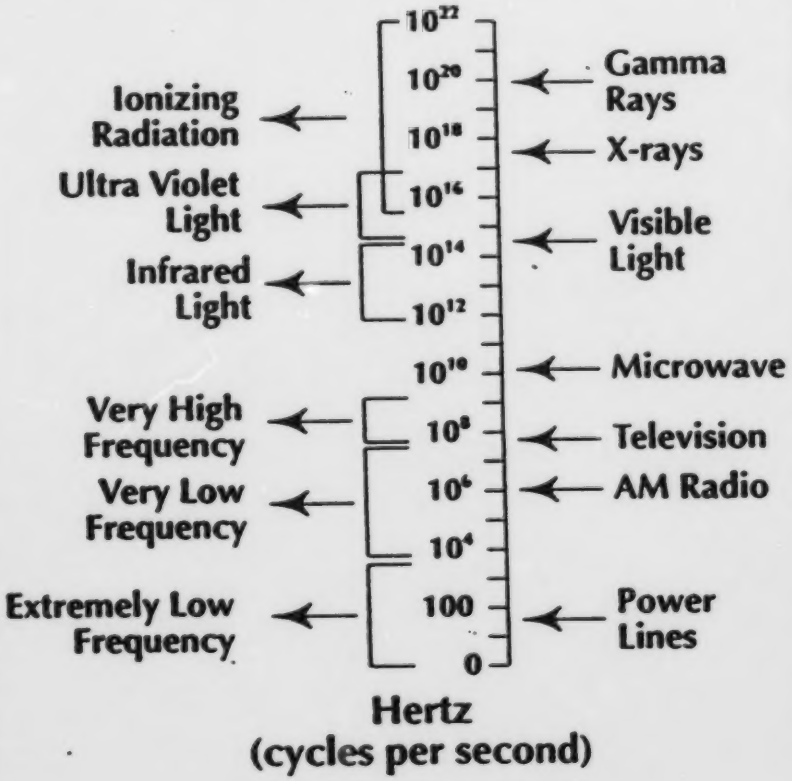
Electromagnetic spectrum is broadly classified according to cycles per second (Hertz)

ELF – Extremely Low Frequency fields (ELF); at the low end of the electromagnetic spectrum; - power lines are at 60 Hertz

VLF – Very Low Frequency; radio 10^6 Hertz

VHF – Very High Frequency; microwave 10^{10} Hertz

Electromagnetic Spectrum



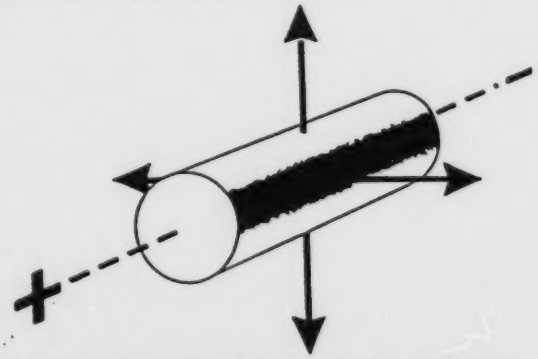
ELECTRIC AND MAGNETIC FIELDS: AC TRANSMISSION

WHAT ARE ELECTRIC AND MAGNETIC FIELDS (EMF)?

The flow and use of electrical energy produce **electric and magnetic fields. Electric** fields arise from the **voltage** on a conductor and can exert a force on charged objects near them. An everyday example of such a force is the static cling that people may experience on their clothing on a dry day due to an electric field between different pieces of clothing or the clothing and skin. **Magnetic** fields can exist as a physical property of certain bodies or arise from **current** flowing in a conductor. The pull of a magnet to a refrigerator door is due to a magnetic field, and the earth's natural magnetic field has for centuries allowed man to navigate the seas using the magnetic compass. Both electric and magnetic fields decrease in intensity as one moves farther from their source.

Electric and magnetic fields, which are invisible, can be represented as lines of force (shown below).

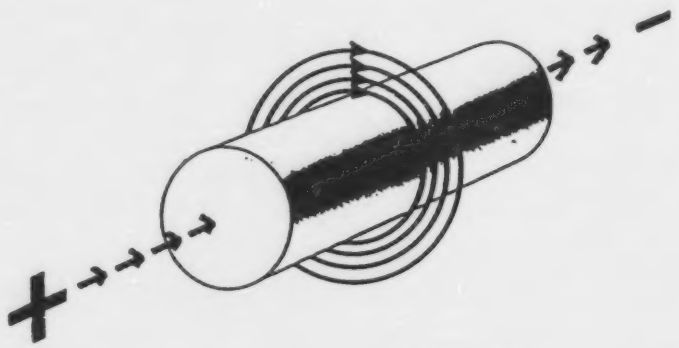
Electric Field from a Conductor



A straight conductor with a voltage applied to it is a source of an electric field, radiating outward like spokes from the hub of a wheel.

Electric Fields are measured in kV/m
- vary with voltage

Magnetic Field from a Conductor

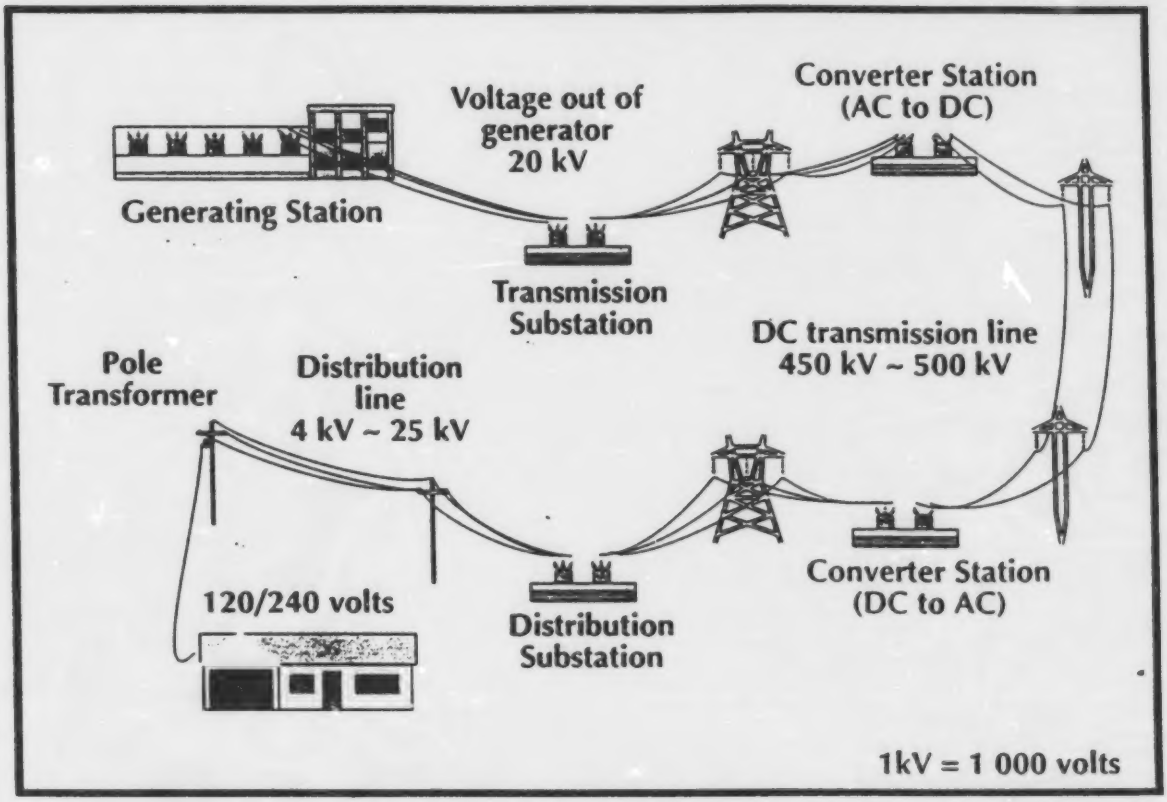


'Charge in motion', ie. current flowing through a conductor, creates a magnetic field in concentric circles around the conductor.

Magnetic Fields vary with current

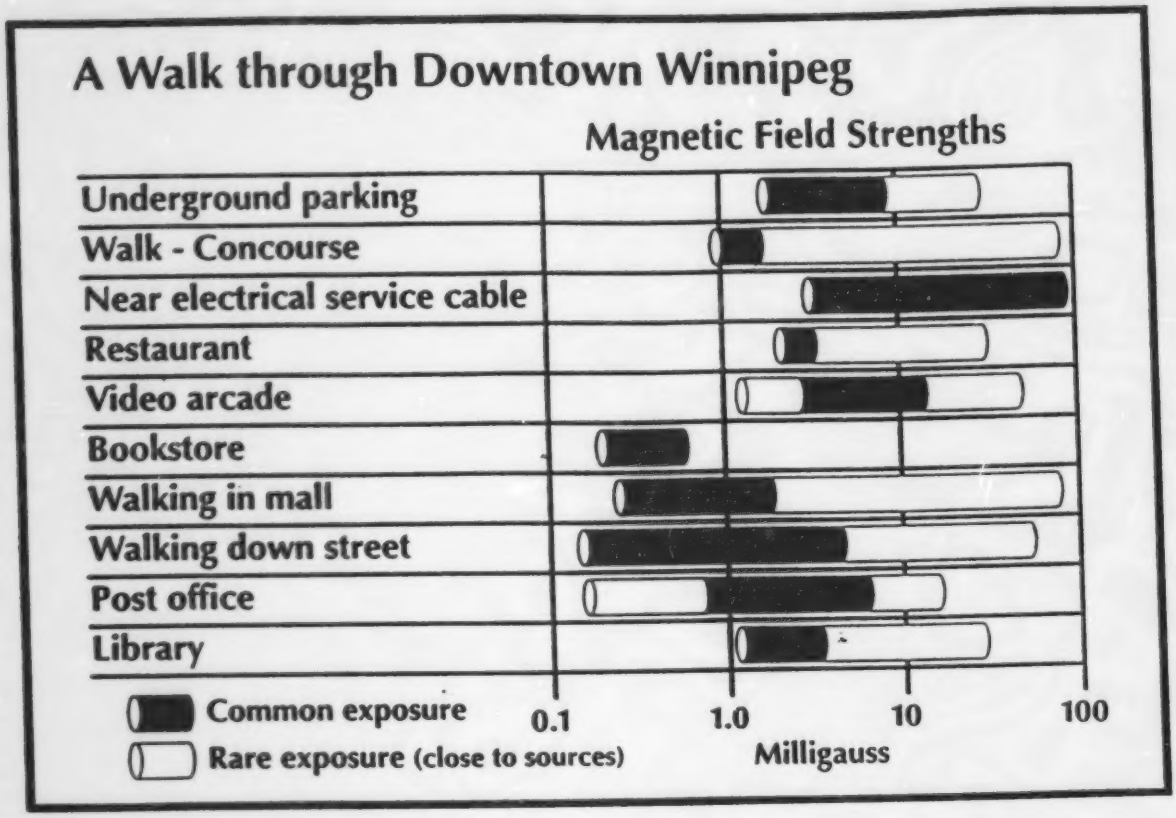
- are measured in
- mT (micro Tesla) or
- mG (milli Gauss)

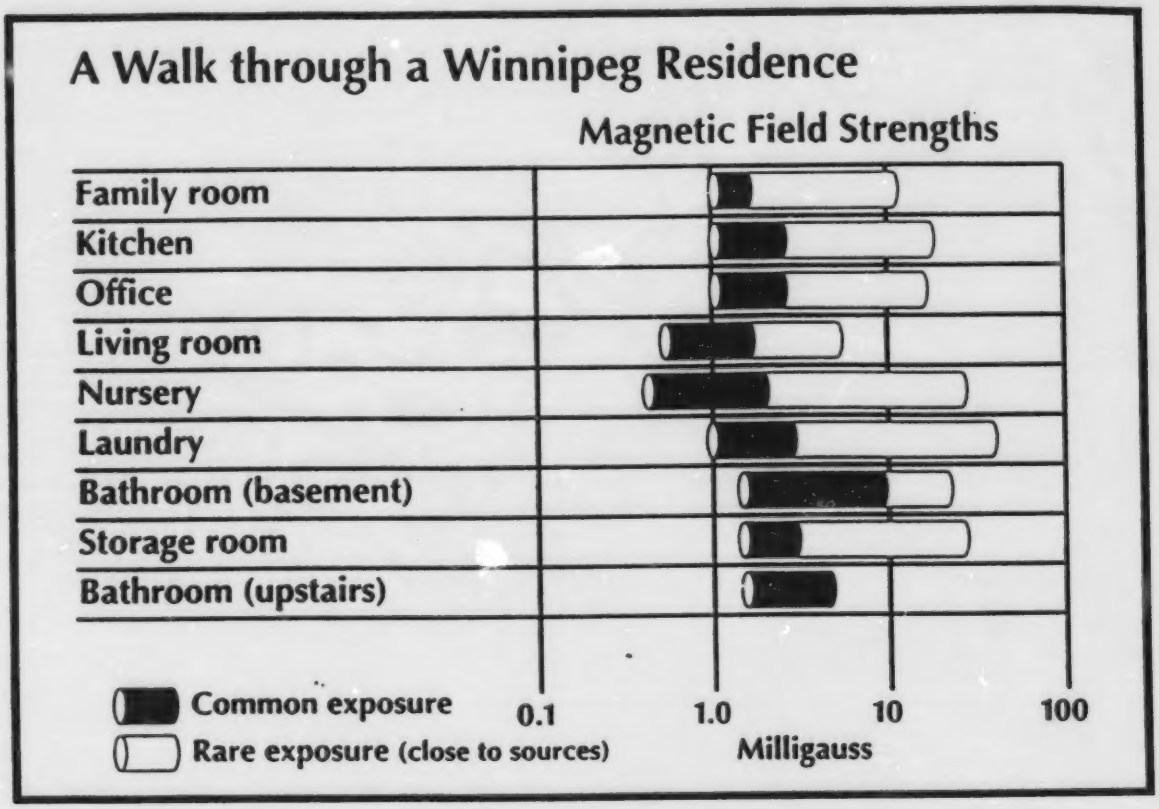
1mT = 10 mG


Converter Station
(AC to DC)
Voltage out of
generator
20 kV
Generating Station
Transmission
Substation
DC transmission line
450 kV ~ 500 kV
Pole
Transformer
Distribution
line
4 kV ~ 25 kV
120/240 volts
Distribution
Substation
Converter Station
(DC to AC)
1kV = 1 000 volts

EMF

- EMF are ubiquitous
  - e.g., our body's nervous system uses electrical impulses
  - the earth has magnetic field
  - electrical power is used virtually everywhere


A Walk through Downtown Winnipeg
Magnetic Field Strengths
Underground parking
Walk - Concourse
Near electrical service cable
Restaurant
Video arcade
Bookstore
Walking in mall
Walking down street
Post office
Library
Common exposure
Rare exposure (close to sources)
0.1
1.0
10
100
Milligauss

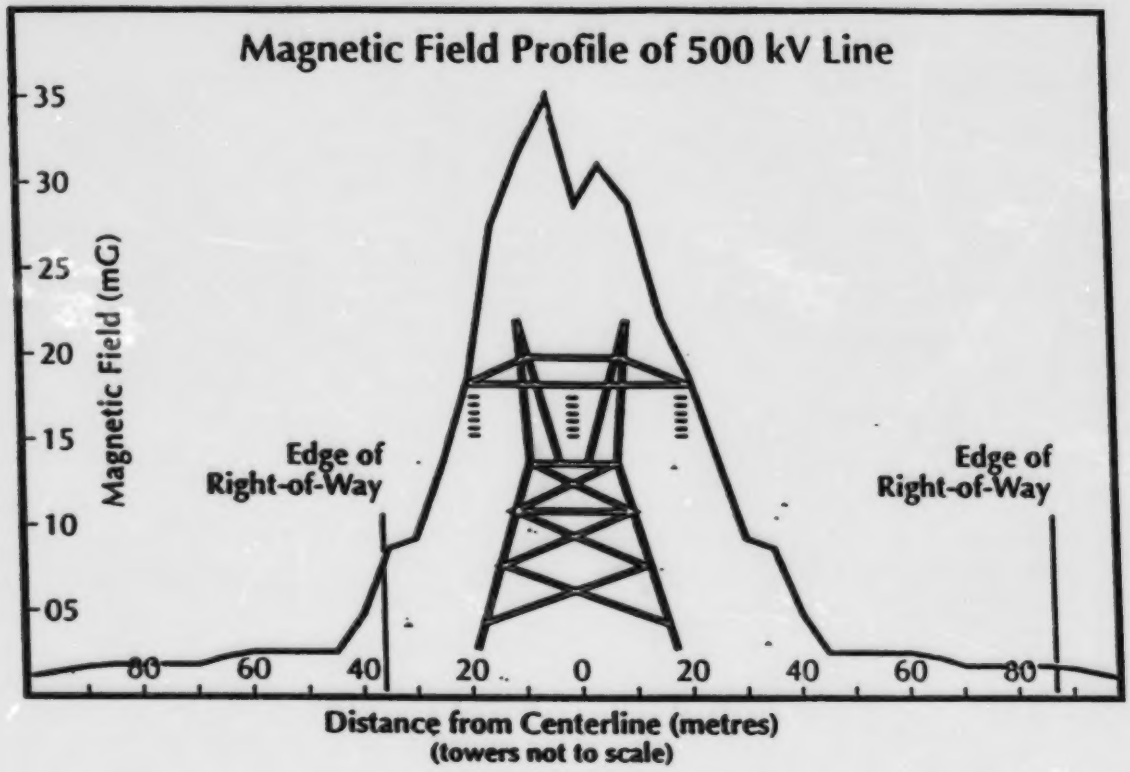

A Walk through a Winnipeg Residence
Magnetic Field Strengths
Family room
Kitchen
Office
Living room
Nursery
Laundry
Bathroom (basement)
Storage room
Bathroom (upstairs)
Common exposure
Rare exposure (close to sources)
0.1
1.0
10
100
Milligauss

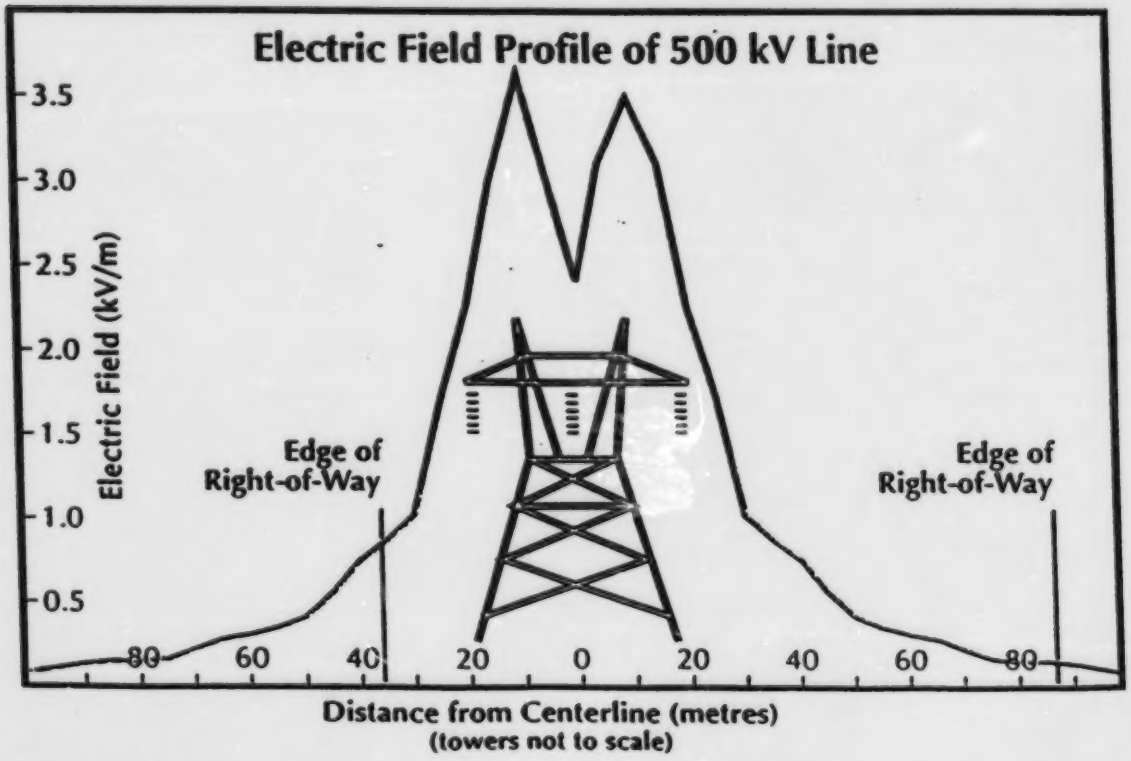
60 Hz magnetic fields at various distances from appliances

Appliance	Magnetic field (milligauss)		
	3 cm	30 cm	1 m
Hair dryer	60-20 000	.1-70	.1-3
Electric shaver	150-15 000	.8-90	.1-3
Portable heater	100-18 000	1.5-50	.1-2.5
Television	25-500	.4-20	.1-1.5
Coffee maker	18-250	.8-1.5	<.1
Refrigerator	5-17	.1-2.5	<.1

POWERLINES AND EMF

- Electric and magnetic fields both diminish rapidly with distance from line
- Electric fields do not easily penetrate most material, magnetic fields do


Magnetic Field Profile of 500 kV Line
35
30
25
20
15
10
05
Magnetic Field (mG)
Edge of Right-of-Way
Edge of Right-of-Way
80
60
40
20
0
20
40
60
80
Distance from Centerline (metres)
(towers not to scale)


Electric Field Profile of 500 kV Line
3.5
3.0
2.5
2.0
1.5
1.0
0.5
Electric Field (kV/m)
Edge of Right-of-Way
Edge of Right-of-Way
80
60
40
20
0
20
40
60
80
Distance from Centerline (metres)
(towers not to scale)

POWER LINES & EMF ISSUES

- There is a history of controversy

  - concerns often arise when a new power line is proposed or a prospective buyer is concerned about purchasing a home adjacent to a power line

  - concerns relate to property value, aesthetics, and human health

- As an environmental consultant, experience shows that EMF concerns are raised whenever a new power line is proposed, whether it's urban, rural, or relatively remote settings

POWER LINES & EMF ISSUES (cont'd)

- On one hand, people accept exposure to fields from appliances (e.g., microwaves) and heating blankets

- Many use magnetic fields for therapeutic benefits

BUT

- Concerns persist re low level exposures to power line fields
  - much research, some controversial (27,000 citations in a database since 1975)
  - complex subject
  - body of evidence is growing

MANITOBA HYDRO

- A major hydro-electric producer
  - many long transmission lines (see map)
  - will likely build more transmission lines in future (especially if export market is favourable)
  - will continue to upgrade distribution lines (provide better, more secure service)
- EMF will be a public health issue, even if just a perceived issue
- Hydro power lines are subject to environmental studies and regulatory review
- Hydro has made commitment to safe and environmentally sound electrical services; is therefore very interested in this review (John Chan available as technical resource today)

TODAY

- Explore the state of knowledge re potential effects of EMF on human health
  - what is known
  - areas of uncertainty
  - comfort level with guidelines
- Review what other jurisdictions are doing on this subject
- Test areas of consensus

APPENDIX D

EMF: A PUBLIC HEALTH OVERVIEW

TM

Exponent

Public Health Perspective on EMF Research

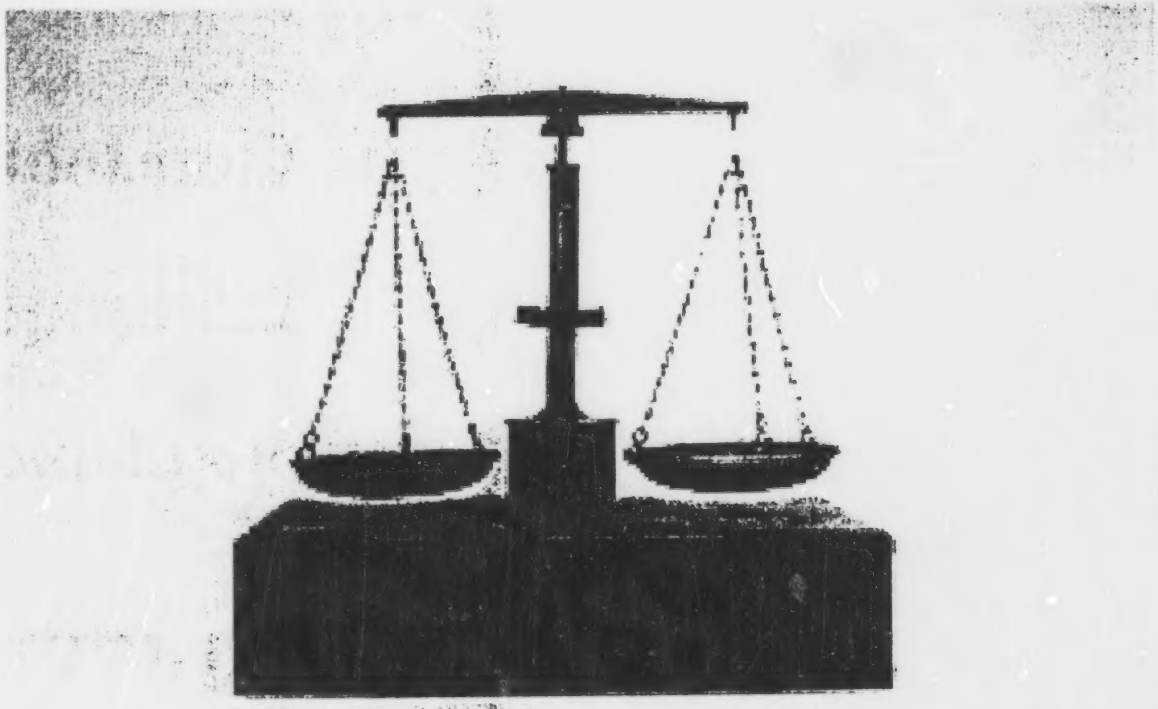
Jack Mandel, Ph.D.,M.P.H.

January, 2001

Role of Science in Public Health

- **Investigation**
  - research (primary)
  - analysis of existing studies
- **Interpretation**
  - weight of evidence
  - characterization of potential risk
- **Limitations**
  - cannot guarantee safety
  - cannot prove that something does not exist

Evaluating the Evidence



How Do Scientists Evaluate Potential Risks of Exposure?

- Epidemiologic studies in humans
- Laboratory studies in animals
- Laboratory studies in cells and tissues

Epidemiology

- Compares characteristics of people with and without a disease or compares disease rates among people with and without exposure
- Statistical associations between people and their exposures
- Observational, not experimental

Individual Characteristics Modify the Effect of Environmental Factors

Genetic factors

Nutrition

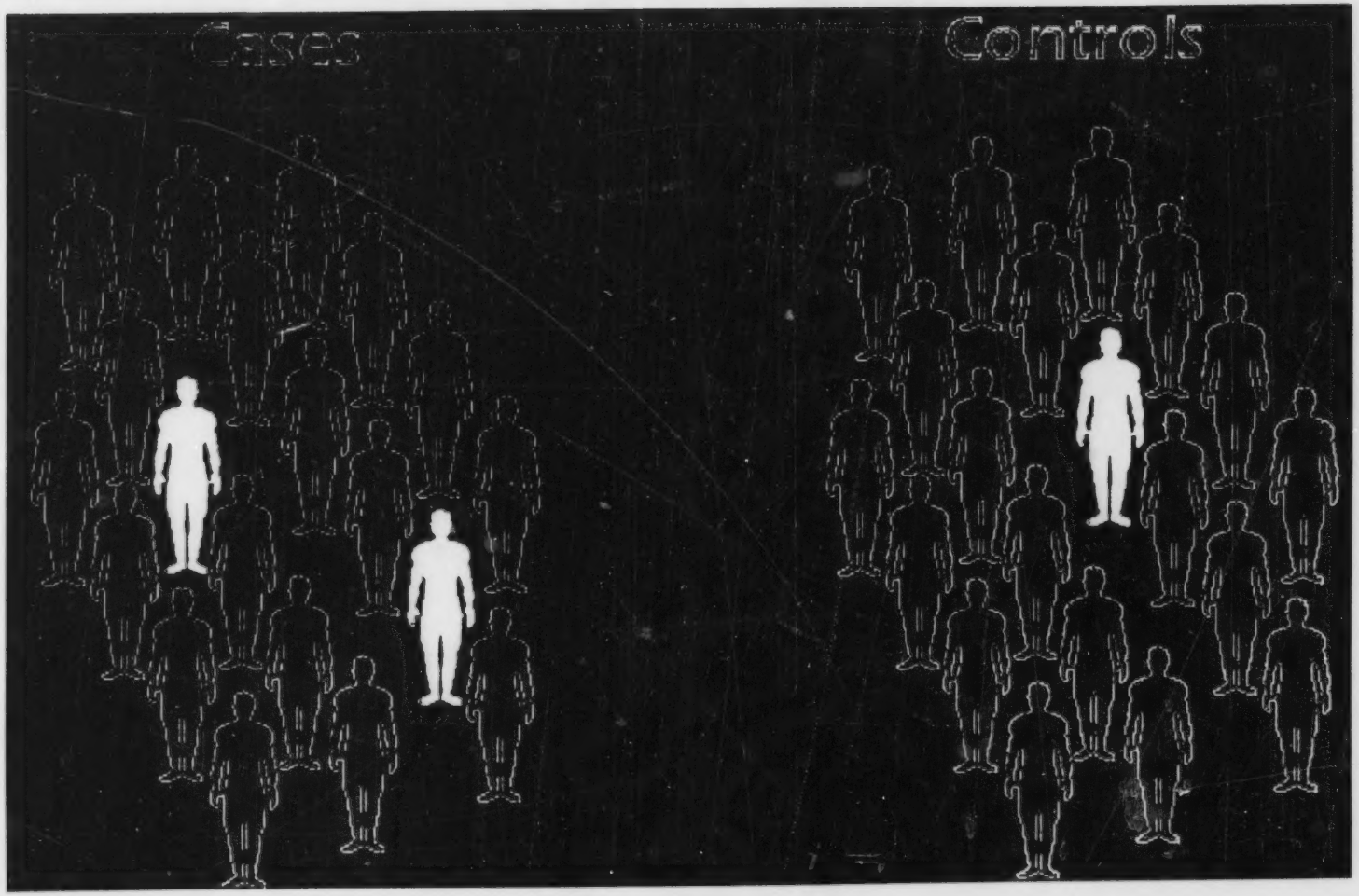
Disease

Gender

Age

Physical condition

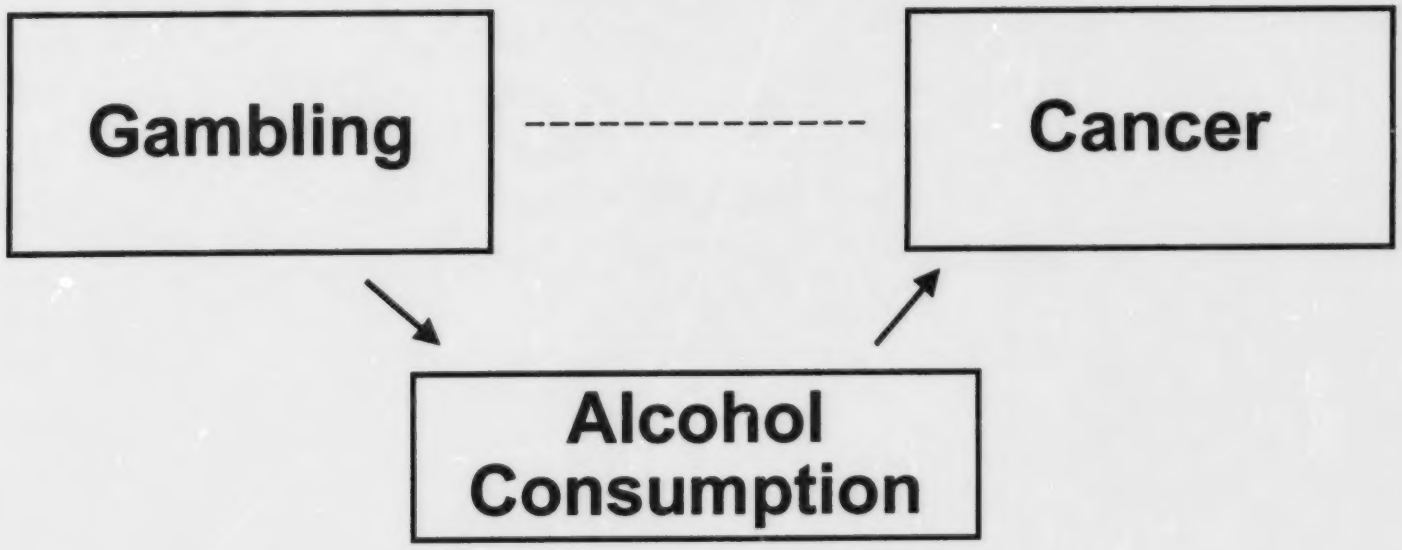
Behavior/habits


Cases
Controls

Statistical Association: An Example

- Cancer occurrence was found to be greater in people who gamble than in comparison populations
- Gambling is associated with cancer

The Association is Indirect



In this example, alcohol consumption is a confounding factor

Is an Association Causal?

- Strength
- Specificity
- Consistency
- Temporality
- Dose-response
- Coherence with preexisting knowledge
- Absence of bias and confounding

Epidemiology Studies of EMF Exposure and Cancer

- Studies of residential exposures from power lines – "wire codes," magnetic fields
- Studies of exposures at work
  - "Electrical workers"
  - Magnetic field exposure

Goals of Recent EMF Epidemiology Studies

- Improve exposure assessment
- Study larger populations with high exposures
- Focus on specific diseases, e.g., subtype of leukemia

Origins of EMF Concerns

The EMF and cancer issue began with study reported by Wertheimer and Leeper in 1979. It received considerably more attention with the publication of the study by Savitz et al. in 1988.

Leukemia and EMF

Recent Studies

- **Linet et al (1997)**
- **McBride et al (1999)**
- **Green et al (1999)**
- **UKCCS (2000)**

Overall, no causal association between leukemia and wire codes.

Association Between Childhood Leukemia and Wire Codes

Study	Subtype	UG	UG +VLCC	OLCC	OHCC	VHCC
Green et al, 1999	Mixed	1.00+ (76)	_	0.81 (41)	0.76 (26)	0.77 (6)
McBride et al, 1999	Mixed	1.00 (67)	_	0.70 (65)	0.69 (78)	0.77 (30)
Linet et al, 1997	ALL		1.0 (175)	1.07 (114)	0.99 (87)	0.88 (24)
Peters et al, 1995	Mixed		1.0 (34)	0.95 (66)	1.44 (73)	2.15 (43)
Savitz et al, 1987	Mixed	1.0 (22)	0.45 (2)	0.80 (23)	1.45 (16)	1.98 (6)

+odds ratio
(number of leukemia cases)

Methods Used to Estimate Exposure

Linet et al	McBride et al	Green et al
Wire codes W-L, K-S	Wire codes W-L, K-S	Wire codes W-L, K-S
	Perimeter meas.	Perimeter meas.
Spot - Interior		Spot - Bedroom - Bedroom + 2 rm - Interior - Outside
	PE – 48 hr	PE – 48 hr

NCI Study of Childhood Leukemia

- **Improvements over previous studies**
  - **Over 600 cases in 9 states**
  - **Exposure assessment closer in time to diagnosis than previous studies**
- **Exposure assessment feasibility study**
- **Alternative exposure estimates**
  - **Wire codes**
  - **Distance**
  - **Exposure index**
  - **Measurements**

(Linet et al, 1997; Kleinerman et al, 2000)

Results of the NCI study

- **No causal associations with any of the methods used to assess exposure**
  - **Wire coding: No association, nor hint of dose-response trend**
  - **Distance: No evidence of higher risk estimate for homes closer to the line**
  - **Exposure Index: Most risk estimates less than 1.0**
  - **Measurements: No association with measured dose and no significant dose-response**

'Positive' Association in the NCI study?

- **Overall, risk estimate=1.2(0.9-1.8)**
- **Elevated risk estimate, 0.400-0.499 μT based on 10 cases and 2 controls**
- **Not elevated (1.01) for > 0.5 μT**
- **No significant dose-response trend**

Authors' Conclusions

"Our results provide little support for the hypothesis that living in homes with high time-weighted average magnetic fields or in homes close to transmission or distribution lines is related to the risk of childhood ALL"

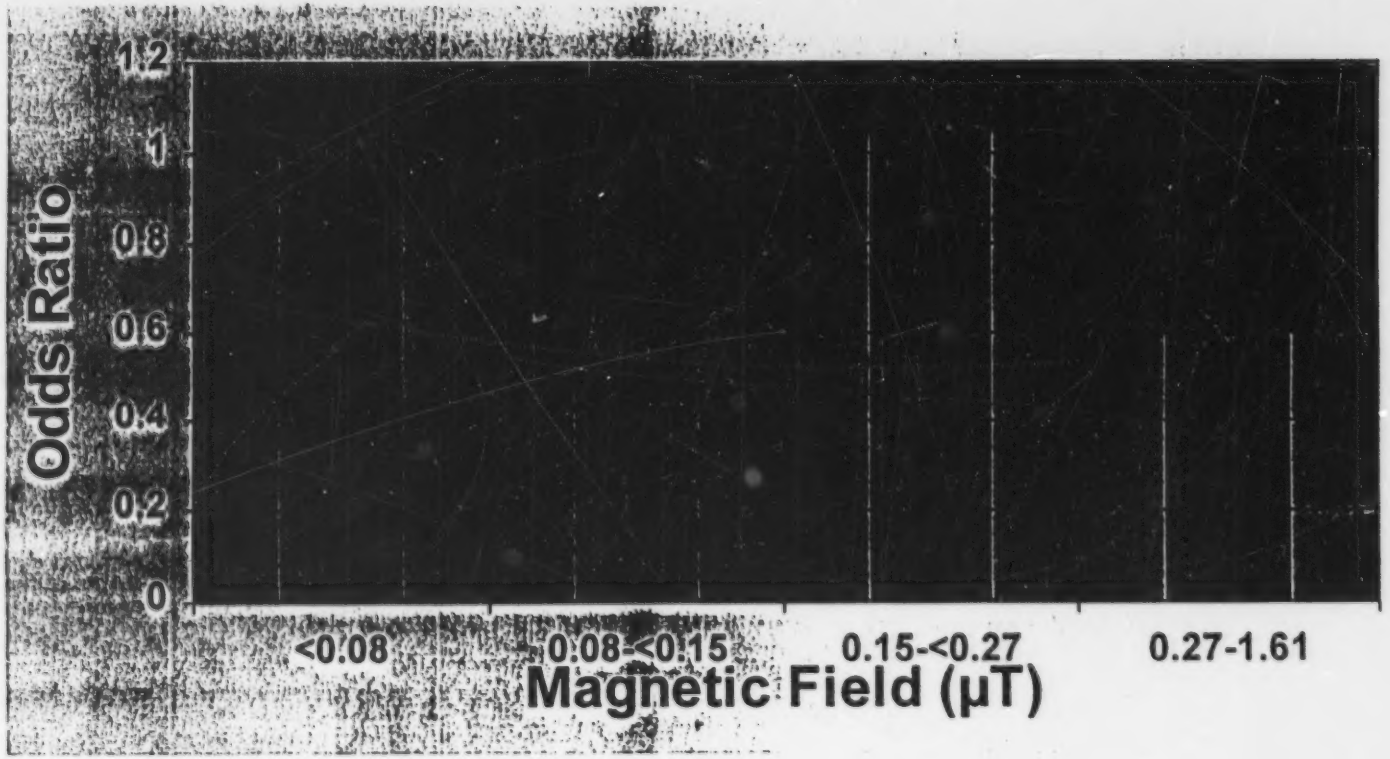
"We found….no evidence that children living near high-voltage power lines are at increased risk of ALL"

Linet et al. and Kleinerman et al. 2000

McBride et al (1999)

- Childhood leukemia
- Provinces (AL, BC, MA, SA, QU)
- 399 cases, 399 controls
- Exposure estimates
  - 48-hr personal electric & magnetic field(backpack)
  - 24-hr EMF measurement in child's bedroom
  - residence perimeter & front door
  - wire coding of nearby power lines

Association of Childhood Leukemia with 48-hr Personal Exposure (McBride et al. 1999)



Authors' Conclusion

"In summary, this investigation which examined several measures of EMF, including personal exposures, offers little support for the hypothesis of an increased risk of childhood leukemia either from magnetic or electric fields or from residential power line configurations."

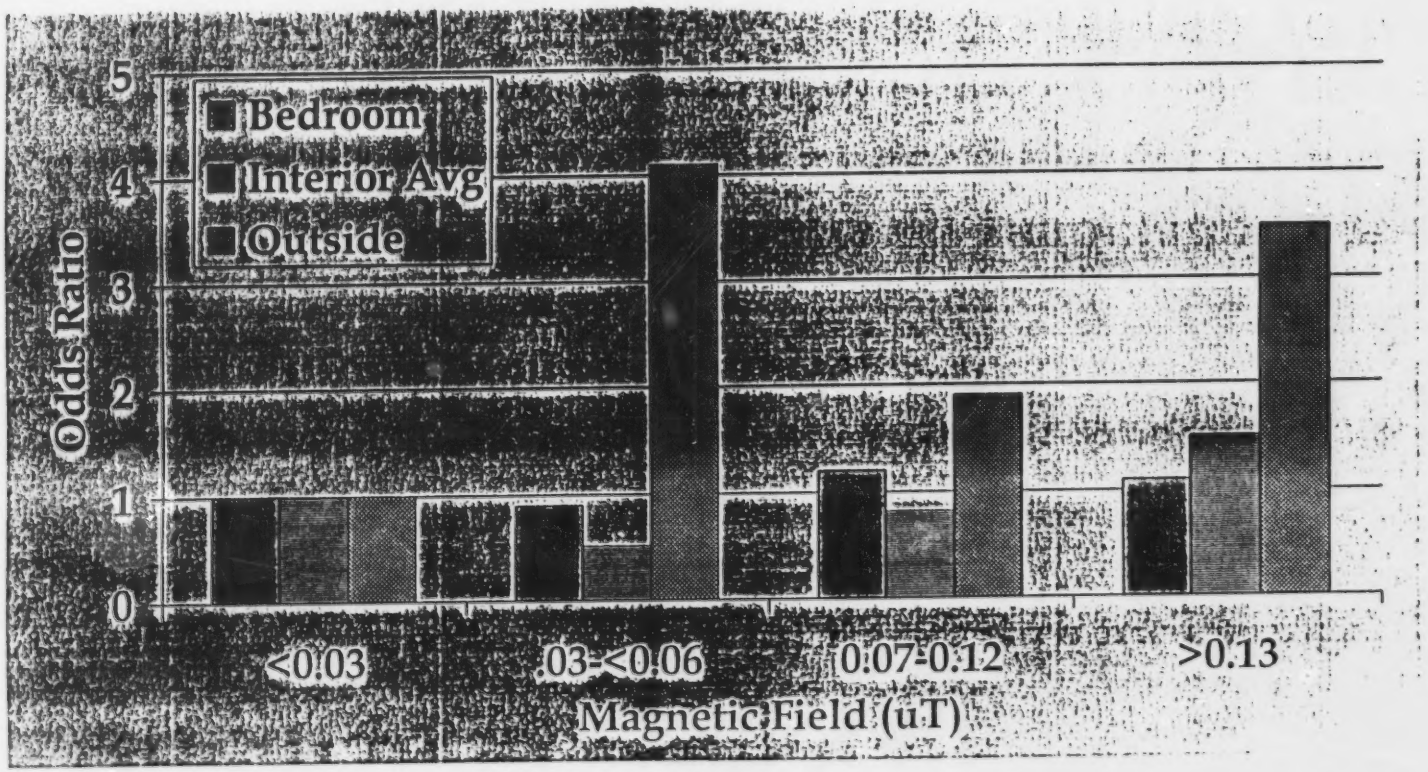
McBride et al. Am J Epidemiol 1999;149:831-42

Green et al (1999)

- Childhood leukemia
- Ontario, 1985-93
- 88 cases, 133 controls
- Exposure estimates
  - 48-hr personal magnetic field exposure
  - spot interior, exterior, and perimeter measurements
  - wire coding of nearby power lines at current residence

Association of Childhood Leukemia with Spot Measurements

(Green et al, 1999)



Green et al Conclusions

- "There was no evidence of a pattern of increasing risk with higher wire configurations."
- Spot measurements "showed either a weaker or no relationship with increased risk."
- Personal monitoring "supports an association between magnetic fields and the risk of developing childhood leukemia, particularly in young children … as measurements of magnetic fields are refined from surrogate indices of personal exposure such as wire codes or point-in-time measurements (to more direct measures) an increased risk of childhood leukemia becomes more evident."

Methodological Issues in Green et al

- Selection of controls (telephone marketing lists)
- Selection of cases (excluded eligible cases who moved out of catchment area)
- Differences between cases and controls
- Rationale for selection of age cut-point (age 6)
- Many confounding factors considered

Canadian Study Differences

- Exposure assessment, statistical analyses, subgroup selection
- Susceptibility to selection bias
- Precision of results
- Adjustments for confounding factors

Adjustments for Confounding Factors

All Leukemia – Personal Magnetic Field Exposure

McBride et al, 1999

- Maternal age at birth
- Maternal education
- Household income
- Ethnicity
- No of residences since birth

Green et al, 1999b

- Daily system load
- Residential mobility
- Family income
- Exp. to agricultural spray
- Glue/solvents/thinners
- Siblingship

Adjustments for Confounding Factors

Green et al, 1999b

- Insecticides
- History of child disease
- Birth defects
- Race
- Mother + x-rays
- Mother + hair coloring
- Mother + clean prod
- Mother's education
- Mother + medications

The United Kingdom Childhood Cancer Study(UKCCS)

- England, Scotland & Wales: 1991-1996
- Tested five hypotheses
  - ionizing radiation: pre- and post-pregnancy
  - hazardous chemicals: pre- and post-pregnancy
  - parental exposure to radiation and chemicals
  - postnatal exposure to EMF
  - response to infectious agents

UKCCS Exposure Assessment

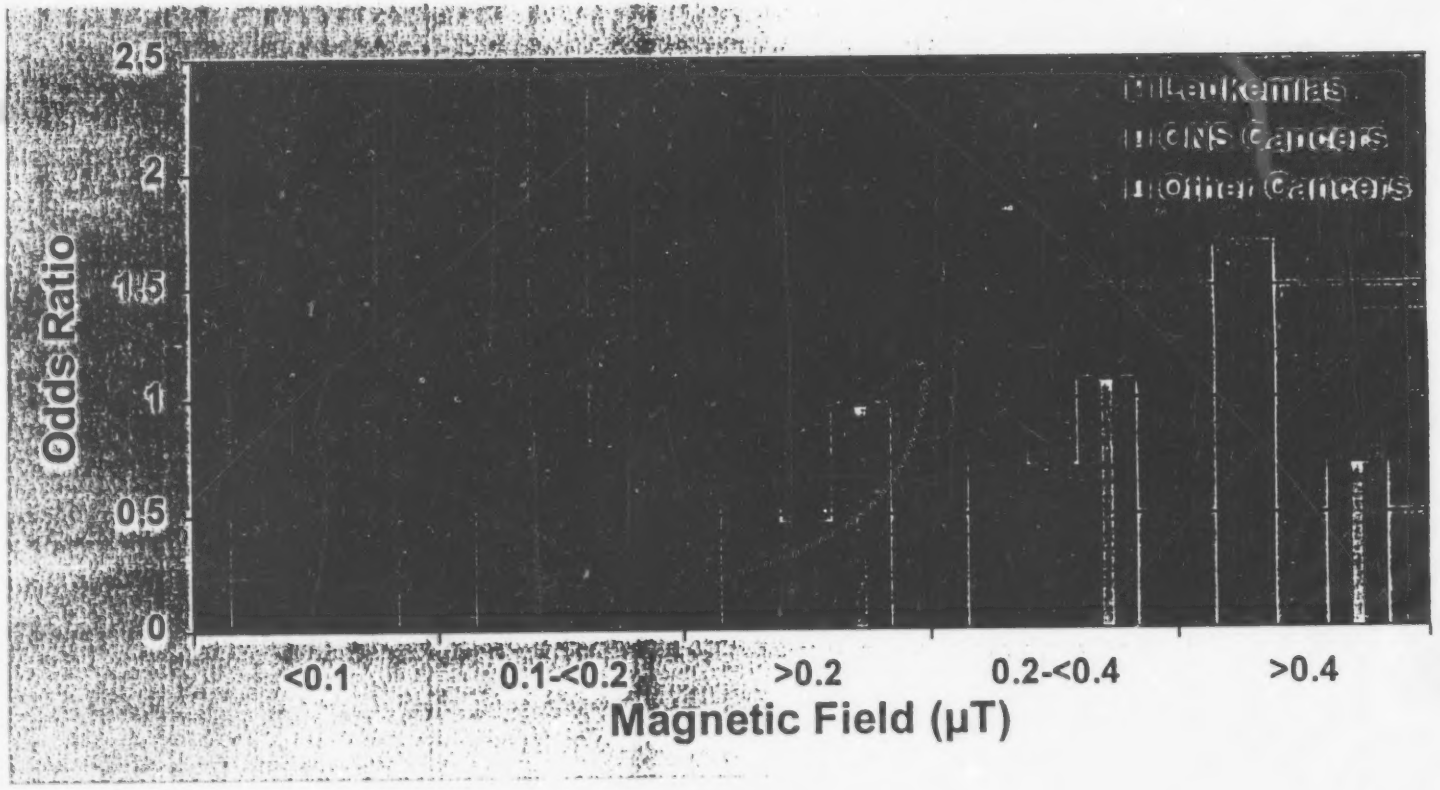
2 Stages

- Stage 1
- Measured fields in homes and schools
- Questions re use of home appliances
- Assembled data on type and distance to overhead power lines and historical load data
- Stage 2
  - Additional measurements in homes of children with highest 10% of exposures

UKCCS Results (1999)

- 2226 cases, 2226 controls
- Estimated exposure in year before diagnosis (or matching date in controls)
- Investigators "found no evidence that magnetic fields associated with the electricity supply increase risk of childhood leukemia, malignant brain (or other central nervous system) tumours, or any other childhood cancer."

Association of Childhood Cancer with Total Exposure (UKCCS 1999)



UKCCS Results (2000)

- **3380 cases, 3390 controls**
- **Estimate exposure in year before diagnosis (or matching date in controls) from calculations based on historical annual average load flows**
- **Investigators report no association with calculated magnetic field at residence or with distance from power lines**
- **"We find no evidence that proximity to electrical installations or the magnetic field levels they produce in the UK is associated with increased risk of childhood leukaemia or any other cancer."**

Measured Average Magnetic Field				**Calculated** Historical Magnetic Field		
	UKCCS (1999)			UKCCS (2000)		
Exposure Level	*N*	*Odds Ratio*	*C.I.*	*N*	*Odds Ratio*	*C.I.*
<0.1 μT	845	1.00		1323	1.00	
0.1-<0.2μT	44	0.69	0.47-1.03	6	1.70	0.58-4.97
≥0.2μT	17	0.92	0.47-1.79	2	0.51	0.11-2.33
0.2-<4 μT	14	0.84	0.41-1.74	1	1.02	0.10-9.96
≥0.4 μT	3	1.51	0.25-9.18	1	0.33	0.04-2.72
Total	923			1331		

C.I. = Confidence Interval

Pooled Analyses

- **Pool the data on *individuals* from a number of studies**

- **Analyze as if it were one large study**

  Ahlbom et al,(2000) pooled 9 studies- 3203 cases

  Greenland et al, (2000) pooled 12 studies - 2078 cases

Associations Between Childhood Leukemia and Magnetic Fields

Estimated Exposure (μT)	Ahlbom et al (2000)	Greenland et al (2000)
0.1 – 0.2	No	No
0.2 - 0.3	*	No
0.2 - 0.4	No	*
>0.3	*	Yes [OR=1.7] (1.2 -2.3)
>0.4	Yes [OR =2.0] (1.3-3.1)	*

* not calculated

Comments: Pooled Analyses

- **Results in the two analyses were roughly similar**
- **Only a small proportion of the subjects were exposed at the higher exposure levels (1-4%)**
- **Limitations increase uncertainty**

  e.g., selection bias, measurement errors, pooling diverse study designs and exposure methods

Authors' Conclusion

"In light of the above problems, the inconclusiveness of the results seems inescapable; resolution will have to await considerably more data on high electric and magnetic-field exposures, childhood leukemia, and possible bias sources."

Greenland et al. 2000

Authors' Conclusion

"In summary, for exposure up to 0.4 μT our data demonstrate relative risks near the no effect level. For the very small proportion (0.8%) of subjects with exposure above 0.4 μT, the data show a two-fold increase, which is unlikely due to random variability. The explanation for the elevated risk is unknown, but selection bias may have accounted for some of the increase."

Ahlbom et al. 2000

Breast Cancer and Electric Blankets

Three recent studies found that there was no association between electric blanket use and breast cancer (Gammon et al. 1998, Laden et al. 2000, Zheng et al. 2000)

Types of Exposure Data in Occupational Studies

Type of Data	Accuracy
1. Personal measurement data	Higher
2. Job specific measurement data	
3. Work History	
4. Job Title	Lower

Occupational Epidemiology

If there is a true effect of exposure, then it should be easier to find in workers with higher exposures

- **Over 100 studies have examined cancer rates among workers in a large variety of 'electrical occupations'**
- **No causal relationship established**

Villeneuve et al (2000a,b)

- Cases and controls were identified in a cohort of 31,543 Ontario Hydro male employees.
- Exposure assessment
  - Positron personal exposure monitors configured to record electric and magnetic fields every minute for 5 days
  - JEM identified 17 job titles and 15 work site locations
- 51 cases of NHL and 203 controls
- 50 cases of leukemia and 200 controls.

Results and Limitations

- Results
  - Both studies report no association between magnetic fields and the incidence of NHL or leukemia.
  - Using 'non-traditional' exposure metrics, the authors suggest that there was some association of electric fields with incidence leukemia.
- Limitations
  - Small sample size
  - 'post-hoc' analysis of 'non-traditional' exposure metrics, e.g. % time above selected values.
  - Uncertainties in exposure history

LABORATORY RESEARCH

- Experimental science - control over relevant variable
- Deals with animals or isolated human tissues
- Can be much more sensitive than epidemiology
- Strength - designed to determine cause and effect relationships

Scientific Studies of EMF Exposure and Health

- Laboratory (animals)
- Laboratory (cells and tissues)

Experimental science — control over relevant variables

Carcinogenicity Bioassays- International Agency for Research on Cancer (1992)

"Besides human experience and epidemiological investigations, long-term studies in laboratory animals are currently the most generally accepted means for determining carcinogenic hazards to public health."

Long-term Studies of Animals Exposed to Magnetic Fields

- NIEHS, 1998
- Yasui et al, 1997
- Mandeville et al, 1997
- Babbitt et al, 1998
- McCormick et al, 1999

Long-Term Studies of Animals Exposed to Magnetic Fields

NIEHS Cancer Study
Exposures: 104 weeks, 18.5 hr/day

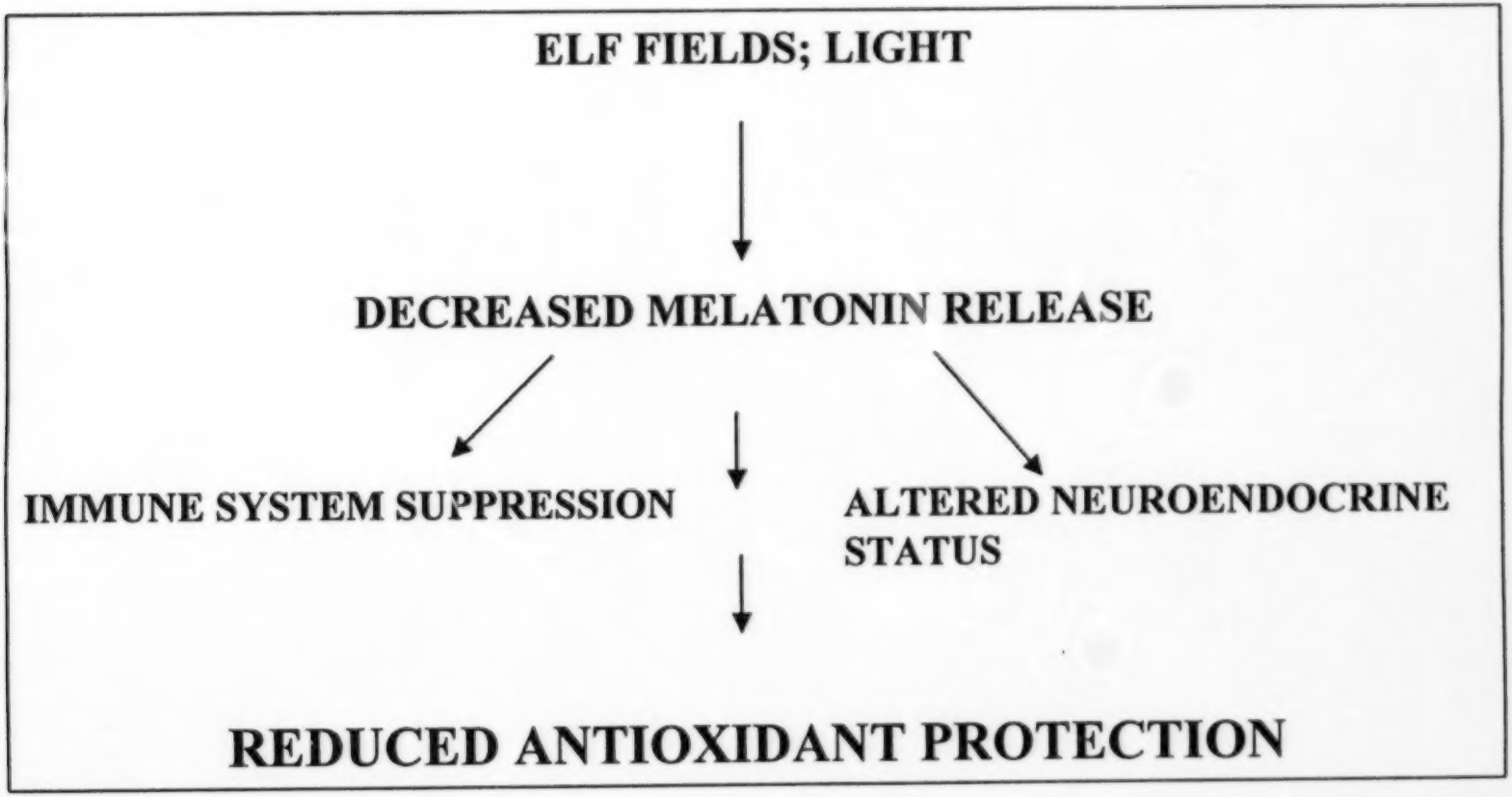
20 mG	Continuous
2,000 mG	Continuous
10,000 mG	Continuous
10,000 mG	Intermittent (1 hr on, 1 hr off)

NIEHS Whole Animal Studies

Testing for Adverse Effects of Magnetic Fields

Reproduction	None
Immunology	None
Melatonin	None
Toxicity	None
Carcinogenicity	None

Melatonin Hypothesis



Melatonin Issues

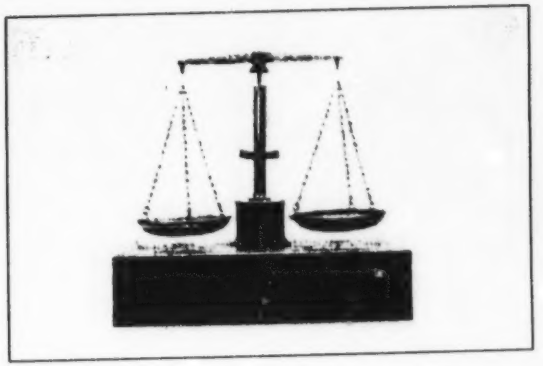
- **Melatonin levels vary widely in the population and vary in individuals within a day, over a week and month and by season**
- **Responses to stimuli, e.g., light vary by species**
- **Animal studies of magnetic field effects on melatonin are inconsistent**
- **Studies reporting effects on melatonin used magnetic field exposures 10-100 times above background levels**

Results of Animal Studies

The mechanistic studies and animal toxicology literature do not demonstrate any consistent pattern across studies. No increase in leukemias in animals has been observed.

Scientific Principles: Strength of the Evidence

- All studies are not equal
- Association is not causation
- Research is evaluated in context



Federal-Provincial Territorial Radiation Protection Committee

"Epidemiology studies suggest a weak association between increased risk of certain types of cancer, and exposure to magnetic and/or electric fields; however the findings are inconsistent and inconclusive."

FPTRPC (continued)

"Experiments with animals and cells show that these fields can interact with biological systems and with cellular chemistry. These interactions, however, have not been shown to lead to adverse health effects."

FPTRPC (continued)

"Research to date has not identified any biophysical mechanisms that link the initiation or promotion of cancer by [to] power frequency field properties."

Sir Richard Doll

"The magnetic component of EMFs has been under suspicion for some time, but this major study provides firm evidence that exposure to the levels of magnetic fields found in the UK does not augment risk for childhood cancer."

Jack S. Mandel

After dozens of studies over 20 years involving thousands of people, there is no evidence that EMF causes cancer. It is time to allay the public's concern and utilize our resources in ways that will improve the public's health rather than on further pursuits of this hypothesis. The absence of clear and consistent findings of risk suggests that there is no causal relationship between EMF and cancer.

Assessment of the Strength of the Evidence (NIEHS 1999)

- The scientific evidence suggesting that ELF-EMF exposure poses any health risk is weak
- The level of epidemiological evidence [for childhood leukemia], while weak, is still sufficient to warrant limited concern
- No other cancers or noncancer health outcomes provide sufficient evidence of a risk to warrant concern

Assessment of the Strength of the Evidence
(NIEHS 1999)

- **The findings of the lifetime [animal] bioassay study are consistent with the absence of an effect on leukemia/lymphoma**
- **Laboratory evidence . . . fails to support a causal relationship between exposure to ELF-EMF at environmental levels and changes in biological function or disease status**
- **ELF-EMF exposure cannot be recognized as entirely safe because of weak scientific evidence that exposure may pose a leukemia hazard. This finding,however, is insufficient to warrant aggressive regulatory concern.**

Sir Richard Doll, Chairman of the UKCCS, believes there is no justification for further epidemiological studies on EMF and childhood cancer in Britain

APPENDIX E

INTERNATIONAL COMMISSION ON NON-IONIZING RADIATION PROTECTION (ICNIRP)

Clean Environment Commission

REVIEW of ELF - EMF

January 25, 2001

Guidelines of the

International Commission on Non-Ionizing Radiation Protection (1998)

H.M. Johnson Ph D
Department of Medical Physics
CancerCare Manitoba

OH1

The International Commission on Non-Ionizing Radiation Protection

Origin:

- » Consider the ICRP
- » IRPA
- » NIR - Working Group
- » The "Commission": Independent Body

Affiliations:

- » World Health Organization (UN)
- » International Labour Organization
- » European Union

Function:

To provide international recommendations of health-based guidance to limit exposure to EMF.

ICNIRP Guidelines

Basis for Limitation

- Short-term immediate health effects:
  - stimulation of peripheral nerves and muscles
  - shock and burns due to physical contact
  - elevated body tissue temperature

- Cancer:

  "Induction of cancer from long-term EMF exposure was not considered to be established … these guidelines are based on short-term, immediate health effects."

ICNIRP Guidelines

Two Classes of Guidance

Basic Restrictions

- restrictions that are based directly on established health effects.
- the basic restriction may be based on a quantity not readily measured external to the body

Reference Level

- parameters and their magnitude that are provided for practical assessment purposes.
- These levels may be derived from the basic restrictions by calculations
- the reference quantities include:
  - » electric field strength **(E)**
  - » magnetic field strength **(H)**
  - » magnetic field density **(B)**

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ICNIRP Guidelines

Coupling Mechanisms Between Fields and Body

1. Low Frequency Electric Fields **(E)**
    - flow of electric charges (current)
    - polarization of bound charges
    - reorientation of electric dipoles

    Effect is dependent on electrical conductivity of the body - which varies with tissue type and field frequency.

    The electric field may induce currents in the body, dependent on size, shape, and position of the body in the field.

Concept: Low frequency electric fields create force fields rather than radiant energy.

ICNIRP Guidelines

Coupling Mechanisms Between Fields and Body

2. Low Frequency Magnetic Fields **(H, B)**

   - time varying magnetic fields induce electric current by exerting a force on electric charges

   - coupling is strongest where loops occur and where loop dimensions are the greatest

ICNIRP GUIDELINES

Basic Restriction (4 - 1000 Hz)

Basic Restrictions: are provided on induced current density (Amperes per square metre)

Observation: thresholds for acute effects in CNS are observed with induced current densities above 100 mA/m^2

Occupation Restriction: exposure to fields should induce current densities less than 10 mA/m^2 (safety factor is 10)

Public Restriction: exposure to fields should induce current densities less than 2 mA/m^2 (safety factor is 50)

ICNIRP GUIDELINES

50/60 Hz Standards and Guidelines Limits for Continuous General Public and Occupational Exposure

		Electric Field Strength (kV/M)		Magnetic Flux Density (microtesla)	
Standard		**Public**	**Occupational**	**Public**	**Occupational**
ICNIRP (1998)	(60Hz)	4.16	8.33	83	416
USA, ACGIH (1998)	(60Hz		25		1,000
CENELEC (1995)	(60Hz)	8.333	25*	533	1,333
UK NRPB (1993)	(60Hz)	10	10	1,333	1,333
Australia, NH&MRC (1989)	(50Hz)	5.0	10.0	100	500
Germany (1989)	(50Hz)	20.6	20.6	5,000	5,000
USSR (1975)	(50Hz)	-	5.0	-	-
USSR (1985)	(50Hz)	-	-	-	1,760
Poland (1980)	(50Hz)	-	15.0	-	-

* with time restrictions

ACGIH – American Conference of Governmental Industrial Hygienist
CENELEC - Comite' Europeen de Normalisation Electrotechnique (European Committee for Electrotechnical Standardization)
ICNIRP – International Commission on Non-Ionizing Radiation Protection
NH&MRC – National Health & Medical Research Council
NRPB – National Radiological Protection Board

ICNIRP Guidelines

Reference Levels (25 - 820 Hz)

Values for the following parameters are derived from the "Basic Restriction" parameter.

Parameters	Occupational	Public
Electric Fields, **E** (V/m)	$\frac{500}{f} = 8{,}300$	$\frac{250}{f} = 4{,}200$
Magnetic Field **H** (a/m)	$\frac{20}{f} = 330$	$\frac{4}{f} = 67$
Magnetic Flux Density **B** (Micro-tesla)	$\frac{25}{f} = 420$	$\frac{5}{f} = 83$

Note: *f* is kilo hertz for ICNIRP calculations.

Ref. Tables 6, 7; ICNIRP (1998)

OH8

ICNIRP Guidelines

Safety Factors for Reference Levels

ICNIRP View: "EMF guidelines should relate to the precision of science, reflecting the … established information on biological and health effects of EMF exposure, … free from vested interest."

Safety Factors: Occupational / Public

Reference Parameter	Safety Factor ("O / P")
Electric Field	2
Magnetic Field	5
Magnetic Flux Density	5

ICNIRP Guidelines

Samples of Coupling (ICNIRP, 1998, p 5100

A. Homogenous conductivity of 0.2 Siemens/m 50 Hz magnetic flux density of 100 microtesla generates current densities 0.2 to 2.0 mA/m^2 in the peripheral area of the body.

B. 60 Hz; magnetic flux density: 100 microtesla corresponds to average current density of 0.28 mA/m^2, maximum of 2 mA/m^2.

C. Electric field sector is perpendicular to the body: induced current densities varies inversely with body cross section - greatest in neck and ankles.

e.g. 5 kV/m; worst coupling model; induced current density is 2 mA/m^2 (neck, trunk).

ICNIRP Guidelines

Principle: Limit exposure to fields that induce current densities not greater than 10 mA/m^2 in head, neck, and trunk at ELF frequencies.

"The safety factor may be unnecessarily conservative".

Application: Reference Levels are measurable quantities that can assess whether the induced current density exceeds 10 mA/m^2 under maximum coupling (worst-case) conditions.

ICNIRP recognizes its reference levels are lower than other guidelines. ICNIRP objective is to avoid stimulation of peripheral nerves and muscles.

ICNIRP Guidelines

Consequence of Exceeding Guidelines

"When reference levels are exceeded, this does not necessarily mean that the basic restrictions will be exceeded".

Investigate further. Near-field conditions, localized and non-uniform exposure may occur. There may be compliance due to weak coupling.

Physics, engineering, and biological technical advice is required (models of coupling; method of measurement; equipment design and/or shielding).

ICNIRP Website

APPENDIX F

REVIEW OF EXPERIENCE: HOW OTHER JURISDICTIONS DEAL WITH EMF CONCERNS

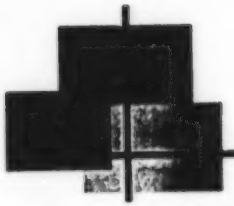
EMF WORKSHOP

for

CLEAN ENVIRONMENT COMMISSION

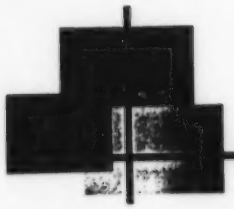
Presentation on Canadian procedures by

TETR*ES* CONSULTANTS



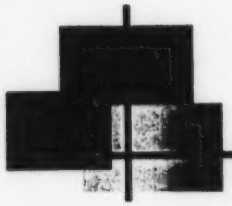
PURPOSE

- Determine EMF practices followed by other Canadian jurisdictions
- Document policy trends and changes
- Contribute information towards value judgments and CEC consensus report



APPROACH

- Reviewed study purpose
- Reviewed existing, in-house documentation and conducted intensive Internet search
  - Focused on potential contacts & policies & procedures for other jurisdictions
- Developed & implemented phone survey



QUESTIONNAIRE

- 8 key questions
- Questionnaire a guide to ensure consistency and completeness of contact information

QUESTIONS

- Key questions asked after explanation:

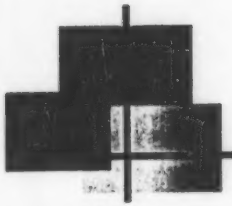
1. What other agencies deal with EMF concerns?
2. What are the main EMF concerns you address?
   Is there protocol for responding to EMF concerns?
3. Are there any presently or planned provincial EMF objectives/guidelines generally or in powerline siting?
4. Can you suggest provincial EMF publications?
5. Can you recommend other contacts regarding EMF?

PEOPLE SURVEYED

- 22 of 32 (69%) people contacted responded to survey
- All Canadian provinces surveyed
- Contact database:
  - Attempted contact with all Provinces and agencies identified as having important information
  - 54 of 81 potential contacts identified are Canadian
- Only 1 non-Canadian response:
  - ICNIRP Chair (Alastair McKinlay) provided input

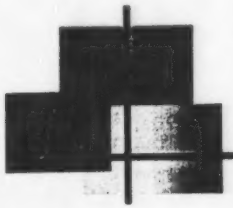
SUMMARY OF RESULTS

- No Canadian provincial EMF guidelines/legislation
  - None in development for Extremely Low Frequency (ELF)
  - Refer to other guidelines, key ones being:
  - Federal-Provincial-Territorial Radiation Protection Committee (FPTRPC) statements
  - ICNIRP and IEEE draft guidelines
  - Guidelines exist for EMF above 3 kHz i.e. not ELF
  - Health Canada (Safety Code 6)
- No provincial policies or procedures in responding to people with EMF concerns
  - There are general trends in types of responses
  - Provincial/corporate representatives distribute information
  - Some conduct site-specific monitoring, where warranted
  - Utilities communicate regularly & track ICNIRP & IEEE



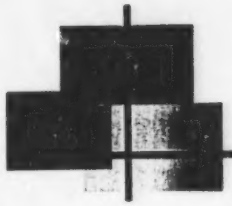
ATLANTIC PROVINCES

- Nova Scotia and Prince Edward Islands seldom/never deal with EMF issues
- Neither these nor New Brunswick have or are developing EMF policies or guidelines



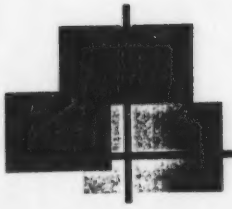
QUEBEC

- Hydro Quebec is active in EMF research
- EMF concerns addressed by Hydro Quebec:
  - Health and t-line environmental issues
- No EMF policies or guidelines at present
  - None in development
- No avoidance policy for siting powerlines
- Quebec Ministry of Health & Social Services
  - Developed "Follow-up Committee on Studies on the Health Effects of High Voltage Lines"



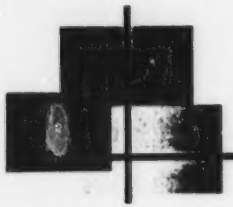
QUEBEC POSITION ON EMF

- Position of Follow-up Committee (Oct 2000):
  - Scientific proof of causal relationship between EMFs emitted by high voltage lines and cancer has not been established
  - Committee supports the *precautionary principle*, since a small risk of childhood leukemia can be attributed to EMF
  - Until ICNIRP revises its exposure limits, Hydro-Quebec should carry out environmental and medical studies and evaluate the feasibility of applying ICNIRP guidelines
  - Committee to follow-up on scientific research carried out in Quebec and elsewhere regarding the health effects of EMFs
  - The Committee will examine the feasibility of applying the recommendations, namely the *precautionary principle*



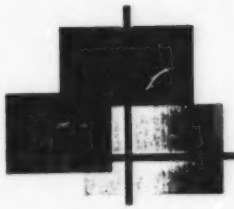
ONTARIO

- Main EMF concern addressed by Ontario Government:
  - Safe distance of transmission facilities from homes
- No Provincial EMF policies or guidelines at present and none in development
  - Respond to concerns, e.g., community meetings
- No avoidance policy for siting powerlines



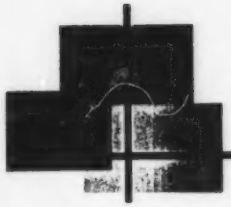
PRAIRIE PROVINCES

- Main EMF concerns addressed gvt. & Hydro:
  - Safety along/near transmission facilities
  - Affect of transmission on property values
  - EMF calls infrequent & cyclical in Sask./Mb.
  - "EMF is not a big concern in Alberta" (1 call/5 yr)
- No Provincial ELF-EMF policies or guidelines at present and none in development
  - Provide information to interested individuals
  - Monitoring site of concern, where warranted
  - Radiation Health and Safety Act and Regulations for EMF above 10 kHz (Sask.)
- No avoidance policy for siting powerlines



BRITISH COLUMBIA

- No Provincial EMF policies or guidelines at present
  - EMF policies are not in development
  - Government refers people to agencies, e.g., Hydro
  - B.C. Hydro has EMF monitoring program
- No avoidance policy for siting powerlines
- Radiation Protection Branch (RPB) and B.C. Hydro (BCH) get frequent EMF-related calls re:
  - Affect of transmission on property values
  - Health concerns along/near transmission facilities
  - Computer monitors & EMF-induced interference
  - Several calls/week (RPB) to 2 calls/day (BCH)

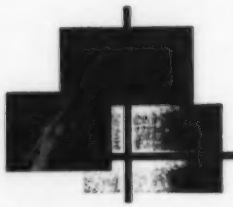


NWT AND NUNAVIT

- Seldom deal with EMF issues
  - Last phone call *re:* EMF 4-5 years ago
  - Concerns expressed by Nunavit is less than NWT
  - No EMF expertise in Nunavit or NWT governments
  - Refer to Alberta & Health Canada for EMF issue
- Neither territory has nor is developing EMF policies or guidelines

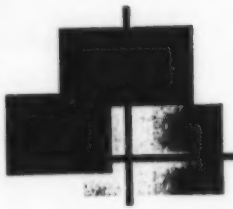
FPTRPC

- Agencies involved in committee:
  - Atomic Energy Control Board
  - Health Canada – Radiation Protection Bureau
  - Provincial and Territorial Radiation Protection Programs
- Developed Health Canada Position statement:
  - "...evidence is insufficient to conclude that electric or magnetic fields cause a risk of cancer." (1998)
- FPTRPC in process of reviewing statement
  - To be discussed at meeting in October 2001
- Evaluating EMF exposure guidelines
  - If developed, may be Canada-wide
  - May require two or more years for development



EMF GUIDELINE STATUS

- Main reasons given by respondents for lack of provincial ELF-EMF guidelines or policies:
  - No recognized EMF threshold re: health effects
  - Process – NIRPB (Health Can.) responds to WHO process in examining guidelines & setting limits
  - Responses few, not warranting development of provincial publications or guidelines



WORLD WIDE GUIDELINES

- Many countries have EMF guidelines and policies
- In 1975, USSR had first ELF-EMF guidelines
- IRPA in 1990 and ICNIRP in 1998 established:
  - High level exposure limits for 50/60 Hz EMFs
  - Next revision of ICNIRP not expected until at least 2004
  - ACGIH also have high exposure limits for workers
- Global trend in EMF guidance & practices?
  - Sweden have ELF-EMF guidance documents
  - ELF limits vary widely between & within countries:
    - Non-standardized exposure levels in U.S.
    - Florida and New York allowable levels:
      - EF – 8-11.8 kV/m on ROW, 1.6-2 kV/m on ROW edge
      - MF –150-200 milligauss on ROW edge

50/60 Hz STANDARDS AND GUIDELINE LIMITS

Standard		Electric Field Strength (kV/m)		Magnetic Flux Density (mT)	
		Public	Occupational	Public	Occupational
ICNIRP (1998)	(60 Hz)	4.16	8.33	0.0833	0.4166
USA, ACGIH (1998)	(60 Hz)	-	25	-	1
CENELEC (1995)	(60 Hz)	8.333	25*	0.533	1.333
UK NRPB (1993)	(60 Hz)	10	10	1.333	1.333
Australia, NH&MRC (1989)	(50 Hz)	5	10	0.1	0.5
Germany (1989)	(50 Hz)	20.6	20.6	5	5
USSR (1975)	(50 Hz)	-	5	-	-
USSR (1985)	(50 Hz)	-	-	-	1.76
Poland (1980)	(50 Hz)	-	15	-	-

* with time restrictions; Source: FPTRPC (1998)

ACGIH – American Conference of Governmental Industrial Hygienists

CENELEC – Comite Europeen de Normalisation Electrotechnique (European Committee for Electrotechnical Standardization)
ICNIRP – International Commission on Non-Ionizing Radiation Protection
NH&MRC – National Health & Medical Research Council
NRPB – National Radiological Protection Board

APPENDIX G

FEDERAL-PROVINCIAL-TERRITORIAL RADIATION PROTECTION COMMITTEE (FPTRPC) POSITION STATEMENT – 1998

POSITION STATEMENT* ON THE HEALTH EFFECTS OF EXTREMELY LOW FREQUENCY (E.L.F.) ELECTRIC AND MAGNETIC FIELDS ON THE GENERAL PUBLIC

1. The production of electric and magnetic fields are associated with the generation, transmission and use of electricity. People are exposed to these fields not only when they are near high voltage lines, but also at their places of work and in their homes. Such fields are produced by distribution lines, transformers, building and house wiring and by all devices that use electric power.

2. Studies to investigate the health effects of these fields have been taking place around the world for more than twenty-five years. Such research has included laboratory studies concerning the effects on cells, tissues and animals, as well as studies on human exposure and Epidemiology.

3. Epidemiological studies suggest a weak association between increased risk of certain types of cancer, and exposure to magnetic and/or electric fields; however the findings are inconsistent and inconclusive. Experiments with animals and cells show that these fields can interact with biological systems and with cellular chemistry. These interactions, however, have not been shown to lead to adverse health effects. Extensive world-wide research programs are ongoing in order to clarify whether or not there are indeed health risks.

4. Research to date[1] has not identified any biophysical mechanisms that link the initiation or promotion of cancer by power frequency field properties.

5. Recommended exposure limits to prevent acute health effects have been put forward by an international committee of experts[2]. It is extremely unlikely that members of the Canadian public would be exposed above these exposure limits. In the case of chronic exposure at ambient levels, currently available information on health and bioeffects does not provide a basis for establishing more restrictive exposure limits.

6. The Federa Provincial Territorial Radiation Protection Committee will continue to monitor the results of new studies and re-assess this position as new information becomes available.

*Position Statement issued by the Federal Provincial Territorial Radiation Protection Committee.

[1]Council of the American Physical Society - (95/04/22)
[2]ICNIRP Guidelines "Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields (Up to 300 GHz)," Health Physics, Vol.. 74, No. 4, pp. 494-522, April 1998. The Guidelines recommend a limit of 4.16 kV/m and 83.3 μT (833 milligauss) for 24-hour exposure of the general public

APPENDIX H

GENERAL DISCUSSION

H.1 EMF DISCUSSION OVERVIEW

Discussions regarding electric and magnetic fields (EMFs) occurred following the presentations. A question and answer period occurred near the end of the workshop. Relevant points of general discussions that occurred during the workshop are described in the following sections of Appendix H.

H.2 RESULTS AND CONCLUSIONS OF KEY EMF STUDIES

United Kingdom (UK) Study

According to Dr. Mandel, the UK study (UKCCS Investigators 2000) stands as a definitive study regarding extremely low frequency electric and magnetic fields (ELF-EMFs). Sir Richard Doll and other investigators associated with the UK study concluded that there is no demonstrable causal link between ELF-EMFs and cancer. To the knowledge of the experts in attendance, there currently were no formal objections or critics to the study, as cited in scientific literature.

National Cancer Institute (NCI) Study

Dr. Mandel indicated that the National Cancer Institute (NCI) is not investigating EMF any further. After reviewing the NCI results (Linet *et al.* 1997; Kleinerman *et al.* 2000), Workshop Participants questioned whether there would be any human health-related effects expected if the EMF exposure levels were 7 or 8 mG (milligauss). Dr. Mandel stated that there would not be an effect, and referred to the numerous controlled lab experiments that used exposure levels much higher than 10 mG and did not demonstrate the presence of any associated health-related effects. He further explained that in the NCI study and other studies, some researchers occasionally recorded high levels of association at intermediate levels of exposure. It was Dr. Mandel's interpretation that this was due to random variation and was not a point of concern. If health-related problems increased with exposure, then the studies should record higher and increasing incidents of cancer at higher levels of exposure, i.e., a trend that has not been shown to occur.

National Institute of Environmental Health Science (NIEHS) Process

The National Institute of Environmental Health Science (NIEHS) process involves the collaboration of scientists in assessing the strength of the evidence of existing research towards development of a common consensus on the potential health risk associated with EMFs. In 1999, the NIEHS concluded that the scientific evidence suggesting that ELF-EMF exposure poses any health risk is weak, but sufficient to warrant limited concern. When asked whether the decision and statement of the NIEHS would change as a result of the UK study, Dr. Mandel suggested that it would depend largely on who is at the next NIEHS meeting. He indicated that many people have disagreed with the NIEHS process and have called for a National Academy of Sciences review.

H.3 TRANSMISSION LINES AND HYDROELECTRIC STANDARDS

Transmission Lines and EMF

Questions were asked by Workshop Participants regarding typical EMF exposure levels along transmission line rights-of-way (ROWs) and the affect on EMF exposure levels associated with having more than one transmission line along adjacent ROWs. John Chan explained that some transmission ROWs would have EMF levels of 25 μT (micro-tesla), which is well below the International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines, i.e., exposure limits of 83 μT for occupational workers. The exposure level would extend to the edge of the ROW, and drop off quickly beyond that point. If there is more than one transmission line, then the exposure level that would be observed is not additive, i.e., EMF levels are not doubled by having two transmission lines alongside each other, but could, for example, be 1.1 fold higher. John Chan indicated that technical factors, including those specified in the Canadian Electricity Association (CEA) and Canadian Standards Association (CSA) guidelines, are considered in establishing ROW width; EMF is not a factor in the decision making process.

The question was asked as to whether there is any technical way of reducing EMFs emanating from transmission lines, such as through using alternative designs or burying the lines. John Chan explained how air is used for insulating overhead transmission conductors. While bringing

the conductors closer together will reduce EMFs, it will increase other electrical effects such as radio interference. The design process balances all of these factors and minimizes the overall effect. There is also a limit regarding how closely the bare conductors can be spaced apart. Mr. Chan used a graph of a typical ROW (showing the EMF levels on and extending away from a transmission line) to explain how the field drops with increasing distance from the transmission lines. He also explained how an individual positioned near a buried cable could be exposed to the same magnetic fields (MFs) as an overhead transmission line. Burying the transmission line does not eliminate the EMF. A person could be closer to the source of an EMF in the case of buried power lines, which are typically 1-2 m below the surface, whereas overhead transmission line conductors are well above the ground (often 15 m above the ground for 230 kV transmission lines). If someone were standing on top of a buried transmission line, they would be exposed to a higher EMF than they would if standing under an overhead transmission line.

John Chan indicated that burying a transmission line increases the cost compared to overhead transmission facilities by about 10-fold for a 230 kV line and about 15-fold for a 500 kV line. It is more expensive to bury transmission lines because buried lines require high quality insulation material and could require oil circulation as a coolant for extremely high voltage transmission lines. Although some low voltage distribution lines (such as power lines connecting to homes and most businesses) are buried, the prohibitive costs for burying transmission lines are the main reason for the lack of any 500 kV underground lines in Manitoba.

Dr. M Fast suggested that EMF levels drop off quickly and become so small extending away from the ROW that the affects on people in neighbouring houses from transmission lines may well be related more to perception and/or to aesthetic concerns than a potential health-related effect associated with EMF.

Mr. Chan indicated that the development of future transmission facilities in Manitoba is necessary from the perspective of an increase in electric load demand, system security and reliability. For example, all of the high voltage direct current transmission lines from northern Manitoba were knocked down during a strong wind event in 1996; Manitobans would have experienced a blackout without the interconnection with the U.S. – which allowed Manitoba Hydro to buy power from neighbouring hydroelectric utilities such as those in the U.S and thereby avoided serious electric power supply interruption.

Manitoba Hydro Standards

With respect to the practices that Manitoba Hydro is following, John Chan indicated that transmission lines are designed to limit the maximum induced current from the electric field generated by a transmission line to a safe level. There is no limit imposed on the magnetic field. Manitoba Hydro raises transmission line conductors to a height that will ensure the 5 mA (milli-ampere) induced current is satisfied. There are also occupational limits to ensure a safe separation between a live conductor and a worker. These "limits of approach" adopted by Manitoba Hydro, which ensure no electricity will flash over to the worker, exceed Canadian Standards Association (CSA) guidelines. Linesmen are allowed to work above the ICNIRP occupation guideline on electric fields of 8.33 kV/m. For extremely high voltage transmission lines such as 500 kV lines, workers are required to wear conducting suits to drain the electrical charges. Occupational guidance specified by ICNIRP and other guidelines are therefore redundant and of little value with respect to the hydroelectric industry since safety issues have already been dealt with by the Corporation in a manner consistent with established guidelines. Mr. Chan was not aware of any complaint of health effects by hydro workers with respect to exposure to EMFs. Dr. Popplow clarified that, with respect to the *Workplace, Safety and Health Act* that Manitoba Hydro's primary safety issues are falls, injuries and electrocutions.

H.4 ELECTRIC AND MAGNETIC FIELD GUIDELINES

International Commission on Non-Ionizing Radiation Protection (ICNIRP) Guidelines

Questions were raised by Workshop Participants regarding how public health professionals should interpret International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines and how it should affect the current activities of health care in Manitoba. Dr. Johnson explained that a person exposed to extremely low frequency electric and magnetic fields (ELF-EMFs) is being exposed to a force field. Drs. Johnson and Mandel suggested that the ICNIRP guidelines define the exposure limit at which a physiological response occurs (e.g., a tingling in the muscles). It does not necessarily mean that someone exposed to that level will develop a health-related problem such as cancer, i.e., there has been no demonstrable causal relationship between EMF and adverse human health effects related to exposure. There was consensus

amongst the health care professionals in attendance that health effects/problems infers a disease or other ailment and that the ICNIRP exposure limits are more accurately defined on the basis of physiological responses.

According to Dr. Johnson, the relationship that Manitoba and Canada adopts with respect to ICNIRP, and whether to adopt the ICNIRP guidelines, is voluntary. ICNIRP guidelines are put forward for national governmental agencies to adopt or not adopt, according to their discretion. Canada has not yet adopted the ICNIRP guidelines for extremely low frequency (ELF) exposure limits. If Health Canada adopts ICNIRP, then the provinces may follow suit; however, the provinces have autonomy and may decide not to adopt a federal position on EMFs. According to Dr. Johnson, the ICNIRP guidelines are very conservative and include safety factors. He does not advocate the acceptance of ICNIRP guidelines for use as exposure limits for the public in Manitoba.

Exposure Limits

According to Dr. Johnson, the EMF exposure limits that are applied to an individual are "peak numbers" that are not averaged by time. Dr. Mandel referred to numerous laboratory animal studies, such as those of the NIEHS, wherein mice were exposed to extremely high EMF levels for long periods, yet did not have any observable health-related effects.

Regarding the rationale for EMF exposure limit guidelines for ICNIRP being 5-fold higher for occupational than the public health, Dr. Johnson explained that some guidelines have different weighting factors than others. Safety factors for ELF-EMFs were modelled after the approach used in distinguishing between occupational and public standards for ionizing radiation. A guideline level for occupational standards for exposure to ionizing radiation that is a factor of 10 higher than the public standard has been accepted because those who are occupationally exposed are under medical surveillance, are typically in better condition than the general public, and derive an economic benefit from an activity that puts them in exposure to EMFs.

World Wide Guidelines

Workshop Participants asked why the "allowable" exposure limits for Germany (public and occupational limits of 20.6 kV/m [kilovolts per metre] for electric field strength and 5,000 μT

[microtesla] for magnetic flux density) were considerably higher than for ICNIRP. Dr. Johnson indicated that there is considerable difference between countries in the EMF exposure limits that are accepted. Dr. Johnson further indicated that the NRPB (National Radiological Protection Board) has suggested that the exposure limits set by ICNIRP are overly conservative.

H.5 HOW CANADIAN JURISDICTIONS DEAL WITH EMF CONCERNS

Manitoba Government and Hydro Response to Public Concern Regarding EMF

The question was raised as to what information provincial public health officials provide to people that have concerns about EMFs. Dr. James Popplow indicated that he received about 12 calls regarding EMFs in the last 5 years. They often related to the presence of a transmission facility next to a property of concern. He suggested that the biggest risk of transmission towers could be avoided by ensuring that people do not climb on structures. He typically provides concerned individuals with a summary of the current thinking on EMFs, i.e., no causal relationship between EMFs and cancer. He sends them the Federal-Provincial-Territorial Radiation Protection Committee (FPTRPC) statement and, if necessary, might refer to findings of the recent UK study that strongly suggest that there is no public health issue. Dr. Fast suggested that she probably would refer an individual having an EMF-related concern to the Consensus Statement produced by the Health and EMF Experts flowing from the Workshop (ref. Section 5.2).

John Chan indicated that Manitoba Hydro employees distribute pamphlets on EMF when they are asked EMF-specific questions. Mr. Chan further indicated that Hydro will need to update the EMF brochure, where is out of date. In some instances, the occupational health official at Hydro refers an individual having an EMF-related concern to Dr. Popplow.

Manitoba Public Health Communication Regarding EMF

Dr. Popplow suggested that, despite the evidence indicating that there is no causal relationship between EMFs and cancer, people will likely continue to associate cancer and transmission lines; for example, in a case where a child is diagnosed with leukemia two years after their family moves near a transmission line. Public health professionals have to be sensitive when

communicating with someone having such concerns and when providing information on the topic of EMFs.

Other Canadian Jurisdictions

Blair McMahon explained that other jurisdictions in Canada have not developed, nor are they planning to develop, ELF-EMF provincial guidelines. Quebec is the only province that has established a provincial committee which adopted a statement that urges Hydro-Quebec to assess the feasibility of adopting the ICNIRP guidelines. The indication from respondents from other provinces was that members of provincial energy boards and health departments primarily refer to Health Canada and the Federal-Provincial-Territorial Radiation Protection Committee (FPTRPC) statements in responding to individuals having concern about EMFs.

H.6 DR. MANDEL'S OBSERVATIONS

Dr. Mandel interprets the results from all credible EMF studies to clearly indicate that there is no causal relationship between EMFs and any health-related disease, including cancer. He suggested that, after all the years of intensive expert review of this issue, it is time for public health officials to take a clear stand regarding EMFs. In his opinion, there are many other significant health-related issues that need to be dealt with (e.g., the rise in child asthma), that the focus and funding of available public health research should be put on other issues of more credible concern and relevance to overall public health.